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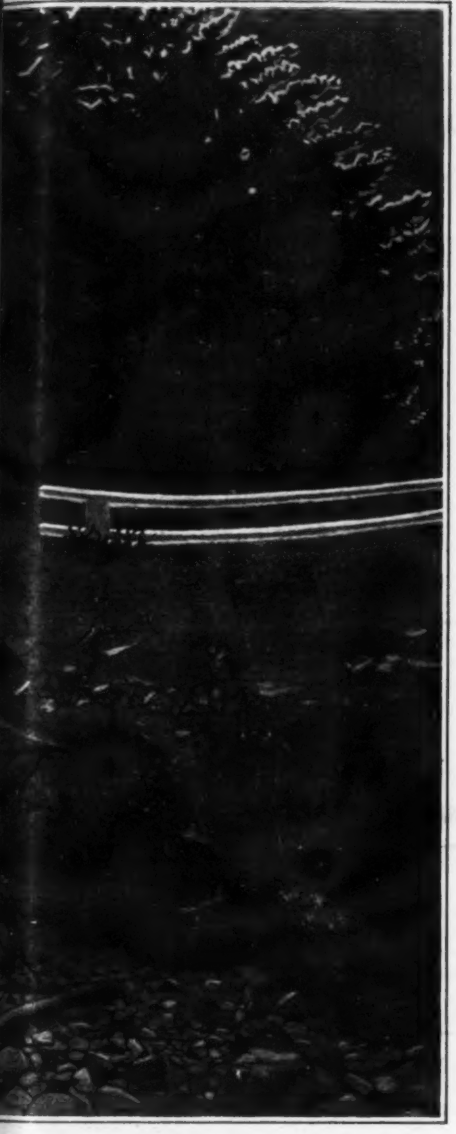

Fig. 5.—View on the bank of the Walchen Lake.

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Fig. 6.—Left-hand illustration.—Same view as shown in center picture as it would appear if seen from under the water.

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Fig. 7.—Right-hand illustration.—A man in water up to his hips, and the view as he appears from below water level.

Seeing Under Water

How Things Look from a Fish's Point of View

By the Berlin Correspondent of the Scientific American

OCEANOGRAPHY, thanks to the many investigations made from a geographical and physical viewpoint, has, during the last few decades, made enormous strides. We are now able, e. g., to gage with a fair approximation to truth, how light is distributed in the depths of the sea or a lake, what gradations of light and color are to be expected at certain depths, and what are the conditions of temperature from the surface down to the bottom. However, nobody seems so far to have examined in a comprehensive manner the question as to what an eye placed below the surface of the water would see and perceive, and what impressions it would receive from this rather unusual standpoint, of its immediate surroundings in the water, but especially of the world outside.

The experiments recently made on vision below water by a German scientist, Dr. Otto Baron v. u. z. Aufsess of Munich, are therefore of more than passing interest and likely to appeal to the physicist as well as to the fisherman and angler.[1] In order better to understand their purport it will be as well, by way of introduction, to summarize the physical conditions on which vision is based:

It is well known that a beam of light striking a transparent substance (e. g., water) of different density from air, undergoes at the boundary a variation in its direction, on account of the difference in the velocities of light in different media. Again, the ratio between these velocities in two given media is a constant figure known as their index of refraction, which is expressed by a mathematical relation between the angles of incidence and refraction, respectively. Since a beam of light entering air from water under an incidence of 48½ degrees is broken along the water surface, those beams which come from angles greater than 48½ degrees can no longer issue into the air, but are reflected in their entirety from the water surface, the limiting angle being called "angle of total reflection."

What, then, may we expect to see on entering the water of a lake and trying to view the outside world from this unwonted position? Presuming the water surface to be perfectly calm, we immediately witness the following remarkable phenomenon: Whereas all objects immediately surrounding us in the water are seen in their natural size and shape, anything situated outside the water, i. e., the whole of the outside world, appears strangely deformed. It is true that objects situated vertically above our heads, i. e., in the zenith (clouds in the sky, etc.) have preserved their true shape; but as our gaze sweeps down toward the horizon, objects will change their wonted forms until at the horizon itself all vertical distances have become so greatly shortened that nothing can be recognized.

What is the reason of this strange phenomenon? In connection with our reference to total reflection we have seen that there are no visual beams connecting the water and the outside world, beyond and angle of inclination of 48½ degrees. In fact, the whole hemisphere of 180 degrees, constituting the outside world, is reproduced in the water within a cone of 97 degrees. While a fish thus is able to see all objects of the outside world—even an angler coming toward the water's edge—he sees everything, with the exception of the zenith, deformed and on a shortened scale. Moreover, the cone of 97 degrees just referred to is, at the limiting angle of total reflection, lined by a colored fringe due to the dispersion of colors in water, the red edge being turned downward and the blue and violet upward.

The horizon of water dwellers thus is extremely limited as compared with that of dwellers in the air,

(Concluded on page 101.)

[1] *Deutsche Alpenzeitung*, January, 1912.

The Prevision of Earthquakes*

Conditions from Which Seismic Disturbances May Be Foretold

BETWEEN foreseeing and foretelling an unexpected event, there would seem to be little if any difference, beyond the fact that the one may be conducted in private while the other implies publication of some kind. But, to the corresponding words "prevision" and "prediction," somewhat different meanings seem to be attributed, prevision being apparently considered as an approximate, and prediction as an accurate, form of forecast. This, at any rate, is a distinction that will be assumed in the present paper, for the prediction of an earthquake, the accurate forecast of its occurrence at a particular time and in a particular place, is a problem far beyond our powers, and likely to remain so for many a year to come.

It must be admitted, moreover, that this is the only kind of forecast that is of any practical value. It is futile to urge that a great earthquake will occur somewhere upon the globe on a certain specified day, if the particular region to be affected is unknown, as such an earthquake actually does occur on an average more than once a week. And, on the other hand, it is of little advantage to proclaim that a certain area will be devastated at some unknown time within the next few years, or even within the next year, for no population will consent to spend their nights out of doors for so long and so indefinite a period. Until, therefore, we can fix the area in one case, or the time in the other, within fairly close limits, the forecasting of earthquakes can have little practical importance. But the problem is so complex, and at the same time its solution would possess such untold value for the dwellers in seismic countries, that it does seem worth while to examine the progress that has been made in the hope that further knowledge and greater experience may in time to come lead us to the desired goal.

It is clear that if, of the two elements, it be possible to determine only one with accuracy, it is more useful to know the site with precision, and the epoch with somewhat less certainty. At any rate, it is in this direction that hope lies. If we could but ascertain certain phenomena, one or more of which invariably precede a great earthquake, we should be on the high road to success. The phenomena may belong to different categories. They need not be the same in every case. Nor need they be manifest without instrumental or other aid. In all probability the phenomena that herald an earthquake will only be revealed by careful and detailed study; otherwise they would have been discovered long ages ago. Thus, we may at once rule out the favorite portents of past times, such as the appearance of a comet or of strange lights in the sky, the arrival of unusual birds, a dull, heavy condition of the atmosphere formerly known as "earthquake weather," or the depressed feelings of neurotic persons.

If we reflect on the mechanism of a great earthquake, on the enormous masses that are displaced in some cases, on the stupendous forces that are involved, and on their gradual increase until they are sufficient, and more than sufficient, to sweep away the resistance opposed to them, it would seem that there must be some indication of their growth, some sign of incipient motion, that might be revealed by painstaking investigation.

Most earthquakes probably originate at a depth of several, though not many, miles below the surface. The sliding movement along a fault or fracture, to which they are due, usually dies out before the surface is reached, so that no visible effect of the motion is manifest, and it is only by the study of the evidence available that we can determine the position of the fault responsible for the earthquake. But, in a few great earthquakes, the displacement underground is so considerable that it is continued right up to the surface, and there it remains and displays to us something of the magnitude of the region in which the earthquake originates, something also of the nature and extent of the initial movement, until, by the gentle but continual action of the weather, the fault-scarps are worn down and all traces of the disturbance are obliterated.

In the earthquake which visited San Francisco and many another coast-town of California in 1906, the surface displacements exceeded in one respect those of every other earthquake with which we are acquainted. The destruction of San Francisco was due, not so much to the strength of the shock, as to the ravages of the fires which followed it. And the fires spread almost unchecked owing to the dislocation of the water-mains by an extraordinary movement along a fault which has been traced in a roughly northwest and southeast line for a total distance of about six hundred miles from near Cape Mendocino on the north to the Colorado Desert on the south. It was only along the northern half of the fault that movement occurred in 1906. But, for a total length of 290 miles (including some submarine portions), the surface-crust on both sides of the fissure slipped in opposite directions, that on the southwest side to the northwest, and that on the northeast side to the southeast, tearing apart with resistless force every work of human hands that crossed its line. Water mains were cut through, and the severed ends separated. Roads, fences, bridges and piers were split across and their ends shifted by amounts which at the surface ranged from eight to more than twenty feet.

These displacements of course represent the sum of those on both sides of the fault. And this is all that could be gathered from the evidence visible to the unaided senses. The precise nature and amount of the several movements could be determined only by a comparison of the trigonometrical surveys carried out in the district some years before and shortly after the earthquake. By this it was found that both sides had moved in the directions mentioned above, that the maximum movement occurred in the immediate neighborhood of the fault, and that it diminished rapidly with increasing distance from the fault, so that, at a few miles from it on either side of the displacement, if it did not actually die out, it was less than could be detected by the accurate instruments at the disposal of the surveyors. Thus, if a straight line twenty miles long had been traced before the earthquake in a direction at right angles to the fault, the line after the earthquake would have been severed at the fault, the ends separated by about twenty feet, and the portions near the fault curved, so that on the southwest side the concavity would face to the northwest and on the northeast side to the southeast.

Taking into account the magnitude of this extraordinary movement and the concentration of the greatest damage wrought by the shock along the line of the fault, there can be no doubt that the earthquake was due partly to the sudden shift at the last moment, partly to the intense friction that must have arisen with the scraping of the rocks on the two sides of the fault. Earthquakes are by no means rare in California, but many years have elapsed since there was any considerable movement along the fault in action in 1906. During this long interval we may imagine the forces along the fault as gradually increasing until in that year they were strong enough to overcome the resistances opposed to them. Then with great rapidity, but certainly not instantaneously, the sliding movement of each side took place. Months passed before equilibrium was once more approximately attained. Small shocks, each the result of a minor slip, were at first comparatively frequent. A few still occur from time to time, but we seem almost to have reached another period of quiescence, during which the forces are slowly gathering which in years to come will terminate in yet another violent shock.

So far as the actual earthquakes are concerned, these periods of quiescence and gradually increasing forces are apt to terminate somewhat suddenly. But, before the critical moment arrived when the crust gave way, its deformation must have already begun. The imaginary line, referred to above as drawn during the early days of quiescence at right angles to the fault, must have shown signs of curvature before its severance along the fault took place. It is not, of course, necessary to draw the whole of this line. A few points upon it at definite intervals apart would be ample. Even the two groups of four stone pillars, erected two on each side of the fault after the earthquake of 1906, would suffice. These pillars were actually placed so as to afford a simple means of measuring fresh displacements along the fault. But they may also be found to furnish evidence of a coming earthquake by a slight and continual increase in the distance between those on opposite sides of the fault.

It will be obvious that this method of foreseeing earthquakes, for which we are indebted to Prof. H. Fielding Reid,[1] is at present in an early stage of development. Until another earthquake occurs along the same fault we have no conception of the time occupied by the process of preliminary curvature, or whether the displacement occurs as a climax to a rapid increase of curvature. The time involved may be too short to be of practical service. But the method of forecast is well worthy of examination and development. It is quite possible that it may, in cours time, lead to valuable results.

The second method, now to be described, rests o more definite foundation. It depends on observati actually made on the slight shocks which preceded great earthquake that devastated the provinces of Mi and Owari in Japan on October 28, 1891. As in Californian earthquake of fifteen years later, this ear quake was accompanied, or rather caused, by unus fault-displacements which to a great extent left visi traces on the surface of the ground. The actual leng of the displacement was less than in the Californi earthquake. The part of the surface-fault affected w traced for 40 miles, though it is probable that its tot length was not less than 70 miles; but in this c the vertical displacement was considerable. In o place it attained a height of about 20 feet. The ho zontal movement was less notable, and was variable amount from one up to about 13 feet. In additi to the displacement which resulted in this fault-sca there must have been other movements along a m deeply seated fault, which is roughly parallel to, tho possibly branching from, the more conspicuous fa Both faults, as well as other minor fissures which m have been in action, will be referred to here as t fault-system.

A very marked feature of this earthquake was t great number of shocks that followed it. All of them w much lighter than the original earthquake, but many, they had occurred alone, would have attracted attenti as strong or violent earthquakes. At first they curred with great frequency, more than a thousand ing recorded at Gifu during the first week. They w felt in all parts of the fault-system, though more f quently in some than in others. But, after the lap of a few months, they occurred more rarely and came almost limited to definite portions of the fa system, such as the central and terminal regions, a finally to the central region alone. It is chiefly these two respects—great frequency and concentrati of activity—that the after-shocks of this earthquake w distinguished from those that preceded it.

We are indebted mainly to the labors of the la Prof. Milne for our knowledge of the earthquakes this district, his great catalogue of 8,331 Japanese ea quakes during the years 1885-92 providing all the m terials necessary for our present purpose. The a mainly affected by the earthquake of 1891 occupi about 20,700 square miles, but the great majority of t shocks originated within a more limited region about 1,345 square miles, or 13 per cent of the abo This may, for convenience, be termed the "earthqua zone."

During the whole of the eight years the earthquak of the zone were, area for area, more frequent than the region outside. But the relative frequency w far from constant. In 1885 earthquakes were 5½ tim as frequent in the zone as in equal areas outside; 1886, 4 times; in 1887, 2¼ times. Possibly this decli in relative frequency during these three years rep sents merely the fading activity of the after-shoc of the last great earthquake in the same district, whi occurred in 1859. At any rate, in 1887, it reached lowest figure. In the following year the relative f quency rose to 5½, in 1889 to 7, and in 1890 and 18 up to October 27 to 10½. On the next day the gre earthquake occurred, after which, during the remaind of the year, the relative frequency was 139, and du ing 1892, 156, the latter higher figure being probab due to the suppression of sympathetic earthquakes the surrounding district. Thus, the first and most o vious symptom of the coming earthquake was a rap increase in the frequency of shocks in the earthqua zone with respect to that of the shocks in the ar immediately outside it.

Another significant feature of the fore-shocks of th earthquake is their distribution along the fault-syste During the five years 1885-89 they shunned as far possible those areas which, towards the end of 18 became most prolific in after-shocks; their distributi in space was apparently without law. But with t beginning of 1890 a remarkable change took pla There were still one or two districts in which th were more numerous than elsewhere; but, on the who the centers of the fore-shocks cling to and mark o the fault-system that came into action in 1891. Exce for one portion of the whole area, and that is occ pied by mountains, the distribution of the centers fo lows with remarkable uniformity the outline of t fault-system—not only the actual course of the fau scarp, but its continuation to the southeast as well

[1] The California earthquake of April 18th, 1906, *Report of the State Earthquake Investigation Commission*, vol. ii, 1910, pp. 31-32.

* By Charles Davison in *Science Progress*.

the course of the deep-seated fault of which there appeared no actual trace at the surface. Then came the great earthquake, and immediately the whole aspect of the distribution was changed. Thus the second and no less significant feature of the fore-shocks is that, within two years before the earthquake, they not only became relatively more frequent, but were distributed with some approach to uniformity over the entire fault-system.

These two properties of the fore-shocks of the Mino-Owari earthquake seem to be prophetic of the coming earthquake. True it is that, so far, they are only known to foreshadow the occurrence of one great earthquake. But there is reason to suppose that they are not so confined. Think, for a moment, of the probable cause of the fore-shocks. For at least four or five years the forces which at last culminated in the great crust-movement of 1891 had been gradually increasing. The contest became one between these growing forces and the resistance to motion along the fault-system. It is improbable that the resistance to motion would be uniform throughout. At different points there would be regions all along the faults within which the resistance to motion was greater than elsewhere. Until these areas of local resistance were cleared away, there would be no displacement on a great scale. Here and there, then, small slips along the fault would cause a fore-shock, and the effect of the slips in all parts of the fault would be to equalize over the entire fault-system the effective resistance to motion. The further growth of the forces would then precipitate the great displacement all over the fault-system and give rise to the great earthquake to which the fore-shocks obviously pointed.

Thus we have reason to believe that the increase in seismic activity along a known fault, and the tendency to uniformity in the distribution of that activity along the fault, may be heralds of the great crush-movements which cause disastrous earthquakes. The method, of course, can only be of service in countries in which earthquakes are fairly numerous and occasionally violent, and in those alone in which there exists an efficient system for the observation of earthquakes. Such conditions are satisfied at present in but one country. In the empire of Japan about a thousand earthquakes occur every year. They are so carefully studied that few, if any, escape investigation. Every few years one of considerable violence takes place. There can be no country, therefore, in which the practical prevision of earthquakes can be more readily effected,[2] and with more universal advantage.

[2] *Quart. Journ. Geol. Soc.*, vol. 53, 1897, pp. 1-15; Gerland's *Beiträge zur Geophysik*, vol. 12., 1912, pp. 9-15.

The Hydrogenation of Oils and Soft Fats

A New Process That Is Revolutionizing an Industry

THE industries that use oils and fats are being revolutionized by a new process—the hardening of oils and soft fats by hydrogenation. Oils and fats are mixtures of various glycerides, which are compounds of glycerin with the so-called fatty acids. Tallow consists chiefly of stearin, the glyceride of stearic acid; olive oil of olein, the glyceride of oleic acid; palm oil of palmitin, the glyceride of palmitic acid, etc. The glycerides differ greatly in hardness and fusing point. Some, like stearin, are solid at ordinary temperatures, while others, like olein, are liquid. Hard fats differ from soft fats, and these from oils, in containing larger proportions of the harder or more solid glycerides. The chemical formula of stearic acid can be changed into that of oleic acid by subtracting two atoms of hydrogen, and to those of two other acids whose glycerides are found in drying oils, by subtracting four and six atoms of hydrogen. Stearic acid belongs to the class of saturated chemical compounds, while the three other acids just mentioned are called unsaturated, because they are capable of taking up two, four or six atoms of hydrogen, and thus becoming transformed into stearic acid. Transforming unsaturated fatty acids and their glycerides into the corresponding saturated compounds is equivalent to transforming oils and soft fats into hard fats. A practical and cheap process for effecting this transformation would seem very desirable because hard fats have a much higher market value than oils and soft fats.

For this purpose the glyceride molecule has been subjected to every conceivable torture by a legion of experimenters. The olein which is expressed from tallow in candle-making has been hardened with some success by the action of sulphuric acid. The Warentrapp process of converting olein into palmitin by fusion with caustic potash is entirely practical, but its development was checked by a sudden rise in the market value of olein, which found an outlet in the manufacture of soap for washing wool. The present difference in price of crude olein and stearin is not large enough to warrant a costly process of hydrogenation. For this reason catalytic processes are employed.

It was discovered more than a hundred years ago that certain substances cause chemical reactions by their mere presence in small quantities. The most celebrated experiment of this class is the ignition of mixed hydrogen and oxygen by contact with spongy platinum, an experiment first performed by Doebereiner in 1823. This phenomenon is known as catalysis. Substances which, like spongy platinum, incite chemical reactions without undergoing any apparent change themselves, are called catalyzers. According to Ostwald, catalysis is merely an acceleration of a reaction that would be accomplished very slowly in the absence of the catalyzer. Applying this theory to the hydrogenation of oils, it may be said that oil and hydrogen, left in contact with each other for a sufficiently long time—years, or perhaps centuries—would combine to form a solid fat. In the presence of a catalyser this combination is effected in a few hours.

Catalyzers, therefore, are economizers of time.

Platinum is not the only catalyzer; there are many others, including charcoal, iron, copper, palladium and nickel, all of which act most efficiently in the form of fine powder. In the case of gases, at least, catalytic power is apparently dependent on the great extent of surface of the pulverized or spongy catalyzer, and is associated with a remarkable power of absorbing gases. Wood charcoal absorbs 178 times its volume of ammonia, which is thereby compressed into less than one volume, and consequently liquefied, as compression into one-sixth its original volume is sufficient to liquefy ammonia. The absorption is accompanied by an evolution of heat much greater than the heat of liquefaction. The excess of heat is probably due to compression of the liquid ammonia, and perhaps to its combination with the charcoal.

Hydrogen is absorbed in large quantities by various pulverized metals. Palladium absorbs 930, reduced cobalt 153, platinum black 110, gold 46, reduced iron and nickel 19, and reduced copper 4 volumes. The hydrogen apparently combines with the metal, forming an instable hydride capable of disengaging atomic or "nascent" hydrogen, which is more active chemically than ordinary molecular hydrogen. Nickel is a very efficient catalyzer in processes of hydrogenation, although it absorbs comparatively small quantities of hydrogen. This is probably due to very rapid formation and decomposition of the nickel hydride. There is reason to believe that nickel forms two hydrides, one of which contains twice as much hydrogen as the other, and is correspondingly less stable and more active. The more active hydride is formed by nickel reduced from its oxide at temperatures below 300 deg. Cent. (572 deg. Fahr.), the other by nickel reduced above 350 deg. Cent. (662 deg. Fahr.).

The catalytic action of nickel is entirely prevented by the presence of the sulphur compounds which often contaminate hydrogen obtained from water gas, and also by mere traces of chlorine, bromine or iodine. This susceptibility to certain "poisons" is characteristic of catalyzers in general. The life of a catalyzer comprises a period of growth and increasing activity, an adult period of maximum activity, and a period of decline which terminates in death. The duration of the adult period can be prolonged by maintaining what may be called hygienic conditions, including a favorable temperature and freedom from dust, which would clog the pores of the catalyzer.

Whatever the mechanism of catalysis may be, we may admit, with Ostwald, that catalyzers act as accelerators of reactions and, with Arrhenius, that in a nearly homogeneous medium, such as a gas, a solution or a fine powder, the velocity of the reaction is proportional to the concentration of the catalyzer, up to a certain limit. In practice, therefore, a mere trace of catalyzer will not suffice; enough must be used to produce a satisfactory velocity of reaction. The quantity required varies with the catalyzer. In the hydrogenation of oils, 100,000 parts of oil require only one part of palladium, but 500 to 1,000 parts of nickel.

From 8 to 20 cubic meters of hydrogen are required to saturate 100 grammes of oil. Hence a factory treating 50 tons of oil daily would consume more than 5,000 cubic meters of hydrogen daily. The production of this hydrogen by the electrolysis of water is practicable only in connection with cheap and abundant water power. This method is employed in one factory in Lyons, France, and one in Norway.

In general, the hydrogen is obtained directly or indirectly, from water gas, which is essentially a mixture of hydrogen and carbon monoxide, produced by passing steam over red-hot coke. In the direct process the other constituents of the water gas are separated from the hydrogen by condensation at low temperature. In the indirect process, the water gas is used to reduce magnetic iron oxide to metallic iron, which is then reoxidized, with liberation of hydrogen, by a current of steam, the same iron being used over and over. In the older forms of this process it was necessary to heat to redness, by an external source of heat, the retorts in which the two operations are alternately conducted.

Some of the magnetic iron oxide is reduced by the carbon monoxide, the remainder by the hydrogen, of the water gas. Heat is generated in the first reaction and absorbed in the second. By completely purifying the water gas, not only by washing with water, but also by means of iron oxide, as illuminating gas is treated, all sulphur compounds are removed and the activity of the water gas is increased, so that it reduces the magnetic iron oxide at a much lower temperature, and with a preponderance of the first, or heat-evolving, reaction that makes it unnecessary to employ any external source of heat, except the combustion of the small quantity of residual gas around the retorts. The improved process is known as the Lane Joubert process. M. George F. Joubert, to whom the improvement is due, has treated the general subject of the hydrogenation of oils exhaustively in an address to the Société des Ingénieurs Civils de France, from which this article is derived.

The typical process of hydrogenation may be described as follows: The oil is first purified, if necessary, for the removal of substances that would interfere with the catalysis. Some chemically inert substance, in the form of a porous powder, is saturated with a concentrated solution of nickel nitrate, dried, and calcined to reduce the nitrate to oxide, which is then reduced to metallic nickel by hydrogen at a temperature of 300 to 350 deg. Cent. (572 to 662 deg. Fahr.). The catalyser thus prepared is mixed with the oil, forming an emulsion, which is converted into a spray by a jet of hydrogen in a closed vessel, in which the proper temperature and pressure are maintained. The more intimately the reacting substances are mixed, the more can the temperature, pressure and duration of the operation be reduced.

More than a score of processes of this general type have been patented. Nickel oxide, organic nickel salts, and colloidal platinum and palladium have also been proposed as catalyzers. With palladium the temperature of hydrogenation can be reduced to 80 deg. Cent. (176 deg. Fahr.) This would be an advantage in the preparation of substances to be used as food, as the flavor is injured by high temperatures. The costly palladium could ultimately be recovered with little loss by precipitating with an acid or saline solution.

In this connection it is interesting to note the deodorizing effect of hydrogenation on oils, especially fish oils. The Japanese chemist, Tsujimoto, has discovered that the peculiar odor of fish oil is due to a fatty acid which differs from stearic acid only in containing eight fewer atoms of hydrogen. When the oil is hydrogenated this acid is converted into stearic acid and the odor is destroyed. This malodorous acid is apparently saturated first, for even partial hydrogenation of fish oil destroys its odor.

The preparation of foodstuffs presents the most profitable field for the oxygenation of oils, as is clearly shown by comparing the market prices of butter and lard with those of cottonseed oil and fish oil. Several foodstuffs produced by the hydrogenation of oils are used in Germany. The minute quantities of nickel which contaminate the product when the oils contain free fatty acid are apparently quite harmless. This, however, is a matter for careful research and governmental regulation. Fortunately, we possess, in dimethylglyoxime, a reagent which detects one part of nickel in one hundred million parts of a solution.

Other important applications of hydrogenation are to the production of stearine for candles and to the hardening of oils and soft fats for the making of hard soaps.

Improvised Defenses*

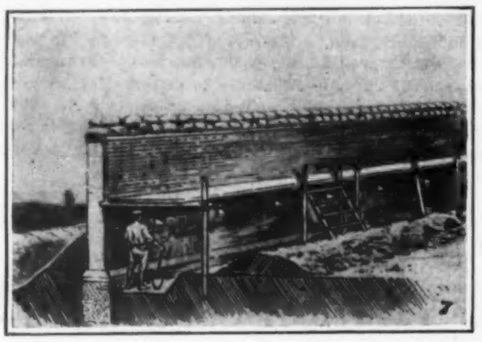
And Devices for the Improvement of Existing Cover

The effective service of a body of troops may be materially increased by the judicious improvement and adaptation of the existing defenses of the country over which the action is being fought. Amongst such defenses are included buildings, hedges, embankments and cuttings, and each of these can be made more effective by treatment which varies in each individual case. A house may be converted into a useful fort by barricading the windows and doors. For the first of these purposes, sacks are filled with stones or earth, and piled behind the door or window, two holes being left near the top to act as loopholes for the defenders' fire (Fig. 1). By another method boards are nailed across the window-frame inside and outside, and the space between filled with stones (Fig. 2). When sufficient loose bricks can be obtained the doors and windows may be thickly walled up from the outside (Fig. 3). A door made to open inward may be secured by means of struts of timber placed at an angle between the door and the floor abutting on a strip of wood nailed to each of these (Fig. 4). A properly built nine-inch brick wall will generally stop a rifle bullet, but a roughly built stone wall should be thicker, so as to reduce the probability of any crevice giving a through passage. A single wall is worse than useless against artillery-fire, as a shell penetrates the wall before exploding, and the damage done by the flying bricks or stones adds to that of the shell-fragments. If a second wall be built a short distance behind the first one, this gives good cover against artillery. In this case contact with the first wall explodes the shell and so prevents it penetrating the second one, which also protects the men from flying splinters.

The shelter given by a hedge growing on the top of a bank is very much increased if a trench be dug at the back of it (Fig. 5), the excavated soil being thrown behind the trench, and care being taken so to dispose of it that it does not attract attention. A line of infantry firing through a hedge from a trench such as that described is very difficult to locate when using smokeless powder.

An embankment may be used either by cutting a trench along its front edge, an operation involving some considerable trouble, in which case the ground in its front will be under fire from it, or, when less time is available, by forming a terrace at its back and firing over the embankment (Fig. 6). The defense of a cutting follows on much the same line, but in this case the "terrace" trench is the forward one, and if both are constructed, the one in the rear may be used for reserves. The defense of a short front by a large number of men when attacked by infantry can be made very effective where a high wall can be used (Fig. 7). In this case a shallow trench is cut at the back of the wall to accommodate one file of men who fire through loopholes made in the wall while another file stand on a platform above their heads, firing through loopholes between sandbags laid on the wall-top.

*The *Illustrated War News*.



An effective defence of a short front by a large body of troops; a high wall divided into upper and lower sections.

Infantry posted behind a wall not more than seven feet high are fairly well protected when firing over the top, but additional protection may be obtained by cutting notches in the top of the wall to act as loopholes. This system gives good head cover, and the notches are very quickly made; but it cannot be adopted in all cases, as the fact that a wall prepared in this way has been put in a state of defense is perfectly evident to the enemy even when it is viewed from a very considerable distance. A platform erected behind a high wall, to enable troops to fire over the top, should be fitted with a handrail behind the men to prevent the wounded from falling. A loophole through a 9-inch brick wall should be about 18 inches long by 9 inches high on the inside surface, and should taper down to about 4½ inches by 3 inches on the outside surface; this arrangement gives free movement through a wide angle, and presents only a small target.

Harvest Disease Due

Although of brief duration, the harvest disease, as it is commonly known, is one of the most annoying and troublesome complaints of the Summer season. It is of frequent occurrence, seldom recognized, and widely disseminated. The disease is generally ascribed to errors of diet, over-exertion or poisoning, and but few of the afflicted are aware that the cause of their suffering is a minute six-legged insect.

The "jigger," "chigger," or harvest mite, which occasions this vexatious Summer eruption belongs to the mite family. This in itself is sufficient to cause some doubt in the minds of the enlightened, inasmuch as several other members of the family have gained fame through misbehavior. The itch mite is a notorious example. It has been with us since history began and still afflicts the human race. The straw mite, only recently discovered, is also acquiring somewhat of a reputation.

The adult jigger is harmless. It apparently loves the freedom of the woods and open fields, attaching itself to leaves and grasses and utterly ignoring all human intruders. The young are hatched in July and August and appear from the eggs as minute orange-red larvæ. For some inexplicable reason they show a considerable predilection for human society, willingly forsaking their natural habitat for the uncertainties of life with man. When lodged upon the skin they immediately select a favorable site and rapidly begin to penetrate the outer layers by burrowing. The trouble begins at this stage. The irritation, at first mild, becomes intense as the burrowing proceeds and is accompanied by redness, swelling and inflammation. Frequently the eruption resembles that of hives or even eczema and the itching is so severe that lesions due to violent scratching may ensue. The irritation may be confined to particular portions of the body or become widespread. Depending upon the number of larvæ entrenching themselves, the suffering may be acute, preventing sleep and even leading to other disturbances, while at the best the degree of uncomfortableness is such as to demand remedial measures. Just why the larvæ exhibit burrowing proclivities in this manner is unknown; their action is apparently without reason as they invariably perish within a few days after commencing their nefarious attack. Their demise is most welcome to the sufferer. As with other parasitic diseases, the susceptibility of individuals varies considerably, some persons not suffering even when thoroughly exposed.

Early treatment of jigger rash or trombidiosis, as it is known, is essential. If the condition is recognized at its onset the sufferer can almost invariably point with exactness to the burrowing sites and frequently the disappearing extremities of the intruders may be observed. A needle, sterilized by boiling, may be used to pluck the invaders from their dermal intrenchments, and even if the search proves unsuccessful, the counter-irritation produced by the instrument is pleasurable, and affords great enjoyment to the afflicted. If the swelling or œdema of the skin is considerable, or if the lesions are not recent, search will prove futile, as the larvæ are already safely buried. One can then only hope for an early termination of their activities, this usually requiring from five to seven days. Several extremely useful preparations are prescribed by physicians not only to kill the mites but to reduce the irritation and relieve the itching. Bathing directly after exposure is advisable in order to drown the parasites. The best treatment is, however, the avoidance of the haunts of the tormentors.

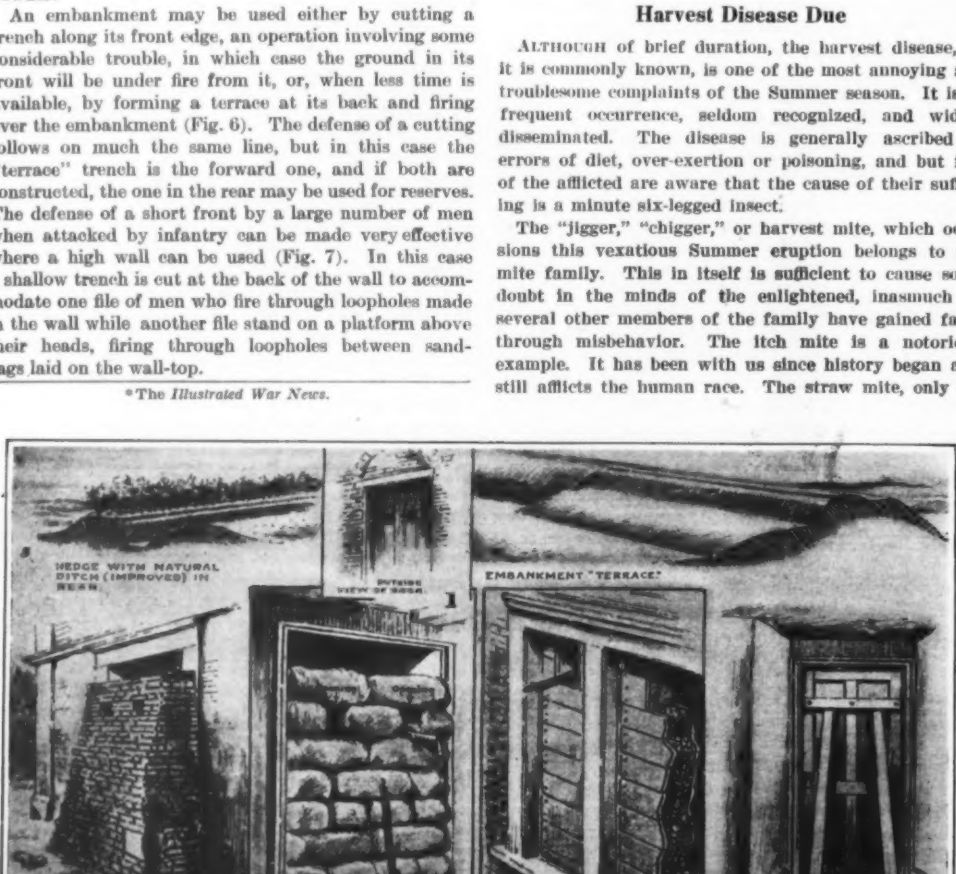
The Time Factor in War.

A mass of men is not necessarily an army any more than a lot of machined castings is a machine—as the Russians have discovered to their cost. The element of time, which is as necessary for the perfection of an army as of a machine, has played an important, almost a vital part in the war. Lord Kitchener has required eight months to "mould, file, equip and assemble" his army; but the big and little guns, without which the army would be only a helpless mob, and the navy little better than merchantmen, are not provided so quickly.

An arsenal capable of turning out a million rifles a year would require a force of nearly 10,000 men working eight hours a day. This estimate is based on the guarantee of the Pratt & Whitney Co. to equip an arsenal for the Australian government capable of turning out a rifle at a labor cost of twenty-three man-hours, complete from butt-plate to the scabbard for the bayonet.

The United States Government required over nine years to produce its first sixteen-inch sea-coast defense gun, not including the time spent on the plans—nine years to make the special machinery and turn out the first gun. The making of the guns, therefore, is only one of the many things that must be considered. The machinery equipment takes years to produce, because for a gun of that size the machinery is all of a special nature.

When shrapnel is being fired at the rate of 200,000 a day, the production of an enormous plant is being used. Each eighteen-pound shrapnel represents, in labor cost, about forty man-hours or five working days of eight hours each, and 200,000 shrapnel means 1,000,000 man-days labor. When we consider that in a general engagement such as is likely to develop in Europe any day the expenditure of shrapnel may be several times 200,000, we gain some idea of the tremendous cost of war and the imperative need of time as well as equipment for manufacturing munitions.—*Machinery*.



The taking of cover is one of the chief arts of modern warfare, and it follows that the improvement of existing defences, natural or artificial, is a matter of equal importance in the operations of troops. The nature of such defences, of course, varies to an almost unlimited extent according to the character of the locality and the kind of materials available for constructing them. The illustrations show a number of typical methods by which houses, walls, hedges, embankments, and so on, can be put into a stronger state of defence for the use of infantry.

Fig. 8.—Hotel on the Walchen Lake.

Fig. 9.—The same hotel seen from below the water.

Seeing Under Water

(Concluded from first page)

while even the form and size of objects in the air appear to them different from what they do to us. However, a person placed in the water will be even more surprised on viewing an object situated partly in air and partly in water.

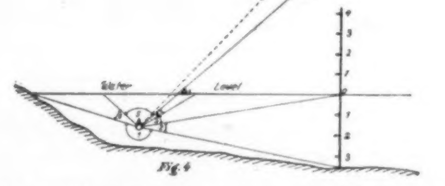
Let us first consider an ordinary measuring-staff, as in Fig. 4 half of which is situated in water and half in the air. An eye placed under the water at *A* sees the submerged portion in its natural shape and size within the angle 2. The portion outside, however, becomes first visible in the cone corresponding to total reflection (angle 5); the upper portion of the staff thus appears in the direction of the limiting angle of total reflection. Being situated immediately above the water horizon, the whole of this portion appears extremely shortened, in fact, as a small object far distant from its direct continuation in the water, in an oblique direction above the water surface. Thus the staff is seen as two separate and altogether dissimilar parts.

Within the angle 3 is seen the *reflection* of the lower portion, and in the angle 4 the remaining lower surface of the water up to the limiting angle of total reflection. In the angular space 1 the eye sees the bottom of the lake from the staff to the bank, and in 6 the reflection of parts thereof.

Observation with the naked eye under water is unsatisfactory because it is impossible to stay under until the surface is undisturbed and one must limit himself to observing his immediate surroundings in the water. As his eye is only adapted for vision in the air, all objects, on account of the different refraction of the water, will appear hazy and without any sharp outlines. The hands and body will have a sponge-like, jelly-fish-like appearance, even the stones on the bottom looking like parts of a pulpy mass. Any more distant objects, for instance, the body of another human being, will appear quite indistinctly, as though through a dim green glass or a greenish haze. Such are the results of Baron Aufsess's actual experiments in the particularly clear water of the Walchensee.

But he has made more interesting observations by means of a mirror placed under the surface.

It was interesting to ascertain whether the silver-white armor of scales surrounding the abdomen of fishes in an outcome of adaptation to a bright reflex actually existing at the water's surface, the fish becoming practically invisible to their foes. The supposition that such a reflection would be visible on the surface wherever on account of total reflection no light is allowed to come out of the water, was found to be erroneous, the water surface being even darker than the surroundings and showing the color of the lake (green or bluish-green). On the other hand, the circle corresponding to the cone of outside vision is extremely bright, and if the surface be even slightly stirred, each wave will produce a flickering glimmer, so that a fish in this region doubtless becomes invisible to his foes, on account of his silver armor.



An eye situated under water sees the submerged portion of a measuring scale in its natural size, and the portion above water separate and greatly fore-shortened.

As regards the appearance of outside objects, houses and trees situated close to the water's edge are hardly recognizable as such, so flattened do they appear, while their lower portions are entirely invisible. Nor are the stones at the water's edge seen any longer; in fact, the roofs of the houses and the tops of trees look as though they rose directly from the water. Even high mountains appear from the middle of the lake as though they were slightly more than low eminences or at most flat hills. Most comical, however, is the appearance of a man standing nearby at the water's edge; his legs nearly up to the knees disappear, only the body being visible from this point, but compressed like a ball. What wonderful colors are, however, shed over this man and his surroundings! His face, arms, hands—in fact everything—is shining in the most beautiful colors of the spectrum, each bough of the adjoining trees, every leaf, is surrounded by a spectrum of its own, so that one could believe the trees to be dotted with shining rainbow pins. Wherever the bright sky is visible through the boughs, red, yellow, green and blue draperies are seen. The distant mountainous banks of the lake appear so flattened as to look like a dark horizontal stroke, but even they have their colored fringe, though only the red and yellow can be distinguished. If, now, the mirror be placed somewhat more obliquely, the true shape of an object is seen to be rendered the more faithfully as it is situated closer to the zenith. Still, it retains the wonderful colored edges above referred to.

Fig. 7 represents the impression received by an eye placed in very clear water, of a man walking up to his hips in water. Will the monster approaching the observer be recognized as a human being? In accordance with the broken appearance of the measuring staff (Fig. 4), the water dweller sees the part of the human body immersed in the water, walking on the bottom of the lake in its natural size and shape. This part of the body, however, is reflected at the same time from the lower surface of the water, thus producing an identical though reversed image with the feet pointing upward as a continuation of his lower body. The upper body, which emerges from the water, first becomes visible in the angular space corresponding to total reflection inside which the outside world is reproduced. It is thus seen from the eye *A* upward in an oblique direction in such a manner that above a colored band on the water surface only the flattened upper parts of the body are visible, surrounded by a luminous colored edge, all the remainder having disappeared. In fact, the man will produce on the water dweller the impression of a strange being. The view toward the stony bank of the lake (Fig. 6) is likewise remarkable. On account of the similarity of the reflection with the real picture of the lake bottom, the eye seems to look into a tapering narrow slit paved with stones on the top and beneath, above which the water's edge appears in the same manner as above described. The reflecting water surface is only visible where it comprises bubbles or floating objects. Figs. 6, 8 and 9 show appearance of building and mountains.

Another method of studying underwater vision was described in the SCIENTIFIC AMERICAN of December 28th, 1912. It involves the building of a subaqueous chamber from which fishes may be watched and photographed. Herewith are two underwater photographs taken by Dr. Francis Ward, showing a heron walking in the water. The mirror effect of the surface of the water is clearly brought out, although the reflection is not perfect because of ripples stirred up by the bird.

German Investments in the Dyestuffs Industry

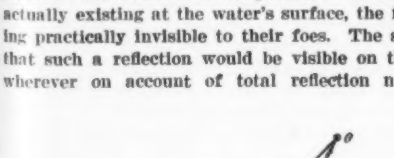
In analyzing the organization of the German dyestuff industry, it will be found that not only a vast amount of brain effort has been expended in its creation, but that also the cash investment has been extremely large.

There are now 22 German establishments devoted to the manufacture of coal-tar colors. Of these 21 are owned by joint stock companies. The combined capitalization of the 21 companies, in 1913, was $36,700,000. In that year they paid dividends amounting to $11,600,000, or 21.74 per cent of the nominal capitalization.

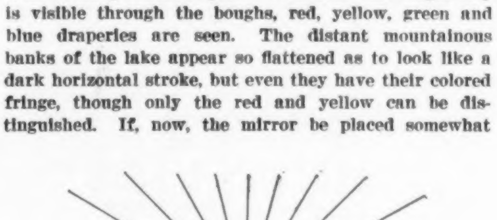
The explanation of this high percentage lies in the fact that for many years the industry has regularly devoted a large share of its profits to writing off the real estate and plant accounts and to new construction. One of the oldest and strongest companies has a capital of $13,100,000. Its stock sells at 600. In 1913 its net profits were $6,000,000, nearly one-half of the capital. One-third of this sum was devoted to a sinking fund for the erection of new plants, etc., and to welfare funds for operatives. From the remainder a dividend of 28 per cent. was paid. This course has been pursued for so many years that it is now estimated that at least $400,000,000 have been invested in the industry.

It is worthy of note that the next most remunerative chemical industries in Germany are those devoted to explosives, glass, heavy chemicals, metallurgy, soap and candles. The factories number 252. Dividends range from 11.2 to 11.8 per cent. Most of the remaining chemical industries in the empire pay dividends of 5 to 10 per cent.

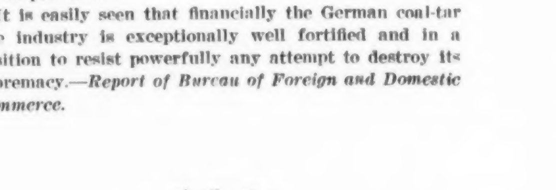
It is easily seen that financially the German coal-tar dye industry is exceptionally well fortified and in a position to resist powerfully any attempt to destroy its supremacy.—*Report of Bureau of Foreign and Domestic Commerce.*



An object AB under water, looked at from O, does not appear at AB, but at A'B' owing to refraction.



The path of light rays incident at different angles upon the surface of water.



An entire hemisphere is reflected under water in a cone of 97 degrees angles.

Dust*

What It Is, What It Does and the Reason for Its Being Where It Is

By William Swaine

In a certain sense we all know what dust is—something very plentiful and often extremely annoying. The housekeeper is plagued very much with it. She sweeps it off the mantelpiece with her cloth, but whither does it go? In most cases either back again to its old place or on to another piece of furniture which very probably has only just been swept clear of it. Since dust is so plentiful one ought to become extremely familiar with what it is, what it does, what are its advantages and disadvantages, and the reason for its being where it is. But it is very questionable whether we give it very much thought.

Dust is found over land and sea, but it is obvious that dust must be more plentiful over the land. However, Dr. J. Aitken, of Glasgow, has devoted a large part of his time to the study of its prevalence. In 1891 he devised an instrument, called a "dust counter," by means of which he has detected and counted particles of dust. The following figures are only very approximate.:

Number of Dust Parts per c.c.	Place.
2,000	Atlantic Ocean
600	Pacific Ocean
500-200	Indian Ocean
As much as 150,000	London, Edinburgh, etc.
14,000-100	Ben Nevis.

Measurements on Ben Nevis have revealed a diurnal range, maximum in the afternoon (ascending air currents), and minimum in the early morning. Approximately for every three thousand feet ascent the amount becomes four-fifths of the number at the lower level.

How many dust particles must an inveterate smoker puff out in a lifetime when with one puff he expels 4,000,000,000, and what must be the number from the exhaust of a petrol motor?

The number of dust particles has lately increased near country roads owing to the great increase in motor traffic—as we all know to our cost. Tuberculosis has been noticed to have become more prevalent amongst cattle grazing near a dusty highway, and in fruit-growing districts the dust clogs the pores of the leaves, causing thereby loss to the gardener.

The causes of excessive dust formation on the roads are chemical, physical, and mechanical, and to-day methods of prevention are of two classes—(*a*) sanitary removal by sprinkling with water or some suitable hygroscopic solid, and (*b*) tar-spraying the roads. The latter method is now largely adopted. Tar-spraying, however, has its disadvantages. Thus in a recent paper we read of the Carmarthenshire Main Roads Committee considering a claim for damages from a bee-keeper whose stock, it was maintained, had all died owing to the tar-spraying of the adjacent road. Fish in streams have been poisoned, thus causing an inquiry into the least injurious tar for tar-spraying purposes. Authorities appear to agree in their ideas of a future road. Hubbard suggests "a bituminous concrete surface with a cement concrete base," and this has been tried in the United States with reasonable success. Sir John Macdonald suggests a carpeted road, the carpet to consist of bitumen and laid on a surface of stone held together by some pitchy substance.

The main causes in the upraising of dust by motors, and so on, are (*a*) cyclonic air currents produced in the rear, (*b*) the great tractive force of the hind wheels, together with (*c*) their uneven turning motion.

Dusts are either harmless or harmful. The dust which flies about the rooms in bakeries and wood turneries is harmless and, according to some people, fattening. Coal dust and that which hangs about the mills of Lancashire and Yorkshire are more or less harmful. According to certain authorities the coal miner is least troubled with lung diseases. Tin miners, quarrymen, potters, stonemasons, and filemakers are, in decreasing order of magnitude, subject to respiratory diseases. Workers in most chemical works are considerably affected by the corrosive action of the chemical dusts. A visit to a soap works reveals the precautions taken by workers near caustic tanks. Even people outside the works have uncomfortable experiences with floating particles of caustic. Then, again, it is only recently that we have had legislation for the improvement of the conditions for the phosphorus worker. Even now "phossy jaw" is not extinct at these works.

In 1868 Tyndall wanted to have air freed from dust as far as possible in order to carry on some delicate experiments. This led him to investigate the nature of dust. He found that if the air in a chamber were kept still, the dust settled and could be received as it settled by some suitable liquid, e. g., glycerine. But it was not freed from dust. Hence he adopted the plan of passing air over a red-hot spiral of platinum wire contained in a tube. This was the purest he obtained. Finding in 1878 that no fermentation took place in his dust-freed air, knowing that fermentation was caused by germs, he arrived at the conclusion that there was some connection between dust and germs. Nowadays we know that what is usually called dust is really multitudes of microbes adhering to genuine dust. It was to Pasteur's credit that the "germ theory" of disease was discovered, and with the introduction of Listerism it has been asserted that "more human lives have been saved than the wars of the last century have sacrificed." The core of Listerism is the use of the carbolic spray with which a wound and the neighboring air are dosed, thus killing any fatal microbes. Now microbes cannot live in fresh air and sunlight, and thus doctors advocate a combination of these two as a preventive. Again, the number of microbes varies directly as the number of dust particles; the smaller the amount of dust the less the number of microbes, and consequently the decrease in pulmonary diseases. What a hot-bed of disease must our dustbins be where organic refuse and coal ashes are thrown to decompose together! As has been stated previously, the higher we ascend the smaller the number of dust particles, and consequently we see why mountain air is so beneficial to persons suffering from consumption.

PHYSIOGRAPHICAL ASPECT.

Represented as a short genealogical tree:

Atmospheric Dust.

Mineral (Salts)	Volcanic (various)	Products of Combustion (carbon, sulphur)	Cosmic or Meteoric (chiefly iron)

Dr. J. Aitken was the first to show that when water vapor condenses in the atmosphere it always does so on some nucleus, e. g., dust particles. His dust counter employs this principle. These are not, however, the only agency. Mr. C. T. R. Wilson has shown that air which is free from dust, but ionized, is capable of having water vapor condensed in it. Very probably phenomena such as fogs, clouds, mist, or rain are due to both these influences, dust being plentiful and ionization caused by the radio-active elements present in the atmosphere, and by sunlight. More recently Dr. Aitken has offered an explanation of fog. If sulphur dioxide be exposed to a strong beam of white light it decomposes, slowly producing a yellow fog of sulphur. Now sulphur dioxide issues forth with other products of combustion from the mouths of chimneys. With the action of sunlight, and a little moisture in the form of water vapor being present, a fog is produced. The characteristics of the London fog are easily explained by this.

The magnificent sunsets which can be seen in different parts of the earth, and the reddish color at both dawn and twilight, are due directly to the presence of dust particles and water vapor. In the morning and evening the light from the sun has to travel through the greatest thickness of air and dust, and since the blue rays are more easily scattered than the red we have the familiar gradation of spectral tints seen at these times. Occasionally there is a second sunset, which is a reflection in the clouds of a more brilliant primary one. These primary and reflected sunsets were much in evidence whilst the Krakatoa dust (Autumn, 1883) was spread in a layer about fifteen miles above the surface of the earth in a broad belt about the tropics, lasting an hour or two after the real sunset. The "Bishop's Ring" was the name given to the coronae which were formed by the sun shining through the dust. These coronae were an outer edging to the sun's disc, blue on the inside, passing through the various colors of the spectrum, the outermost being red. The sunsets at that time were unusually vivid, and the story runs of an American fire brigade setting out to put out an alleged fire at a neighboring village from which the glow appeared to come. But the Krakatoa eruption is not the only instance. After the Messina disturbance a few years ago the sunsets attracted people's attention, and it was noticed in meteorological circles that our climatal conditions suffered a change. In 1783 volcanic dust (traced afterwards from Skaptar Jokul, Iceland) descended on the Orkneys and Shetlands and North Scotland, ruining crops. In this way the dust was carried a distance of over six hundred miles. Coseguina (Nicaragua) volcano, in 1835 threw out enough dust to cause utter darkness for 35 miles radius, and which, when it fell, was 10 feet deep. In 4 days an upper aerial current carried some dust 700 miles. So-called "mud lavas" are really the extremely fine volcanic dusts gathered and mixed by the water, belching forth out of the crater, and often doing more damage than would have resulted from a true lava stream.

Cosmic dust is formed by the disintegration of meteorites owing to friction (they travel from 25 to 40 miles per second) with our atmosphere. The luminosity of shooting stars is due to the rapid combustion of the meteoric dust in the train of a meteorite.

The presence of sodium salts in the air is easily demonstrated by brushing the dust from one's clothes into a non-luminous flame. The characteristic yellow of sodium is much in evidence. Very probably the ocean spray accounts for its presence. Salts of copper have been detected in city air, and accounted for by the electric flashes of overhead cables.

With the chemical we arrive at the most interesting, and perhaps the most important, side of dust phenomena. Until recently it was considered that fire-damp was the sole cause of coal-mine explosions, but experience has shown that within the last 10 years explosions have occurred more frequently in well-ventilated mines. Thus causes have been traced to coal dust which, in the presence of air, is very explosive. Probably the reason is that oxygen in a well-ventilated mine is continually absorbed by the fine coal dust, whilst the neighboring air does not become stale. This combination is very dangerous. Dr. Harger, at Liverpool, consequently suggested "a small reduction in the percentage of oxygen, and the addition of a little carbon dioxide to such an extent as not to be harmful to respiration, and to render coal-dust ignition impossible." He further advised the introduction into the mine atmosphere of flue gases purified from harmful gases and smoke. "It would," he said, "provide immunity, not only from coal-dust explosion, but from fire-damp explosions, and as regards respiration would be as good as ordinary air, and for people liable to consumption better." But the miner does not relish the idea.

Possible dangers of firing fire-damp, or coal dust, are: (1) Lamps of all descriptions; (2) electric leakage causing a spark; (3) blasting explosives; whilst it is advisable that fire-damp should not accumulate. Prof. Thornton has investigated the danger derived from electric sparking. Messrs. Sellars and Campbell, at Manchester, have studied explosions of coal gas and air in the laboratory; but perhaps the most practicable investigations are those employing incombustible dusts as a means of "quenching" any likelihood of the spreading of fire by coal dust. Mr. William Garforth, at Altoft, and Prof. Dixon (by Ryalo Commission), at Eskmeals, are diligently pursuing inquiries in this direction. Bicarbonate of soda and stone dust have been found most efficient; but the fact still remains that these mineral irritants, if inhaled, encourage pulmonary diseases. It is possible, however, to minimize this, and consequently this does not constitute a serious objection. Owing to the continual accumulation of coal dust the stone dust, and so on, must also be replenished from time to time. The idea of keeping the inflammable dust constantly wet in order to render it safe is attended with the serious objection that the miner would have to work under very unhealthy conditions. It must be remembered that the dust must be continually swamped to prevent drying up; a state of affairs much worse than before, since spontaneous combustion is rendered more likely, especially if any sulphide be in close proximity.

Referring to dust which accumulates in flour mills and oil-cake works, Dr. Harger said that ordinary flour mills were on much the same plane as powder magazines. To test this in a small way we only need to enter a flour mill where the cleaner is sweeping the floors, and to see the disturbed dust ignite at some burning gas-jet and endeavor to spread over the whole room. Measurements have shown us that flour dust is much more explosive than coal dust. Even bits of iron, when overheated by friction, are capable of inflaming this highly explosive dust, and thus magnetic screens are now employed to attract any stray bits of iron which may be present.

* From *Knowledge*.

Attempts are being made to utilize coal dust owing to its high calorific value, and it is very probable that it will some day be used to a larger extent. Present-day methods of blowing the dust into furnaces are unsuccessful.

The smoke nuisance dates as far back as Elizabeth, whilst attempts at abatement have been made by J. Watt (1785) and Cutler (1815). The causes are traced to imperfect combustion, due to (*a*) inadequate supply of air, and (*b*) wrong combustion temperature. Smoke in itself is not very harmful, but the sulphuric acid produced from the sulphur in the coal is very injurious, having a very corrosive action, and unfortunately it cannot be eliminated by the various methods adopted for smoke abatement. The study of rain in different places suggests a method of determining qualitatively and quantitatively the constitution of atmospheric pollution. Tests with country and town rains show that town rain is acid, while country rain is neutral. Anthracite stoves are a successful attempt at decreasing the smoke nuisance, whilst experiments are being made with liquid fuel and electricity. Perhaps in the future smoke will be a thing of the past, if Sir William Ramsay's dream comes true, in which our coal will be burned underground and electrical energy stored up at the coalfields. At present, however, the housekeeper can help by using gas-stoves, although they are not very healthy.

The factory, especially so in copper smelting, is very wasteful. Taking the case of copper smelting, a large quantity of metal dust, together with arsenic, is thrown out with the smelter smoke, having disastrous effects on the countryside. Long flues have been found to recover a large quantity of metal, but electrical methods are now employed to better advantage.

Sir Oliver Lodge in 1884 showed an experiment at the British Association meeting in Montreal in which smoke was caused to condense and fall in fine particles by electrical means. By a similar process he managed to clear from fog a space of from 50 to 60 yards radius at Liverpool University, the potential employed being 100,000 volts, dense fogs being dissipated quicker than light ones. This has been applied recently to smelter smoke, and as much as 90 per cent of the metal dust can be recovered. The commercial value of dust is only just beginning to be realized. Wool dust, for example, is now being employed as a fertilizer. In the near future will it be possible to collect road dust in order to extract the rubber worn from motor tires, and for it to be profitable?

To phenomena dependent on dust must be added crystallization and supersaturation—the former needing its presence, and the latter needing its absence.

And what would our world appear like if there were no dust? Very probably the sky would not have its delicate blue color, but would be black, with the sun glaring down on the earth without any diffusion, whilst the stars would be visible during both day and night; and no gloriously tinted sunrise or sunset for the poet or man of science to contemplate. On the other hand, no smoky towns, no dusty highways or furniture, and no fog. But which dusts cause the aesthetic results? Chiefly the volcanic and cosmic—those which we *cannot* help. And which dust is it which causes us so much annoyance, and which is so familiar? That which we *can* help, by altering our roads, our locomotion, our domestic fires, and our factories. However, such is the progress of civilization, and truly "God made the country, and man made the town."

John Muir in College*

JOHN MUIR, whose death has recently been announced, was a student at the University of Wisconsin for a period of four years, beginning in the fall of 1860. My acquaintance with him began in the Spring of 1862, when I entered this department at a young age (fourteen years). After registration, the tutor led me down to the north dormitory. We entered the northeast corner room on the first floor without rap or signal. A young man, of about twenty-two years of age, was there busily at work sawing boards. The room was a strange looking place for the room of a college student. It was my first impression that the tutor was kindly showing me a branch of the college museum. The room was lined with shelves, one above the other, higher than a man could reach. These shelves were filled with retorts, glass tubes, glass jars, botanical and geological specimens and small mechanical contrivances. On the floor, around the sides of the room, were a number of machines of larger size, whose purposes were not apparent at a glance, but which I came to know later. The floor was covered with boards, sawdust and shavings. After looking around a while, the tutor introduced the young man as John Muir, with the remark: "This is your room and there is your roommate." Thus began my acquaintance with Muir, which quickly ripened into a close and delightful college companionship.

It is not commonly known that he was a mechanical genius, but he was, as evidenced by the many mechanical devices that cluttered his room. Time and space will not permit a description of all these devices nor their purposes. I will mention some of them. In the room were two wooden clocks, both of which would keep the time of day, day of the month and month of the year. They were made with saw, jackknife and chisel. One was a perfect farmer's scythe, with two wooden blades; between these blades were placed all the wheels, levers, etc., of a perfect time-keeping clock. The pendulum was a long wooden arrow loaded at the bottom with several copper arrows to give it weight; the escapement was a small and perfect scythe; the escapement points were the handles on the snath, leaving the little blade free to swing back and forth when the clock was running. Every part of this clock was either a scythe, wheel or arrow and emblematical, as Muir used to say to me, of the cutting away of time. This clock was hung in an oak grub as a farmer hangs his scythe. The other clock was a strange affair and more nearly resembled in its structure the framework of a sawmill. It did many wonderful and uncanny things, such as throwing John out of bed in the morning and at a predetermined time; picking a cap off a fluid lamp and lighting it with a match while he was on the floor rubbing his eyes; building the fire in the country school-house where he taught in the Winter months. All these things it did without a miss.

The study table was another curious and amusing device which Muir made for his own use. It had little resemblance to a table; the legs were wooden compasses and imitation wooden books. The top was slanting and made of a series of cog wheels, the centre wheel being solid and about fourteen inches in diameter. This wheel was cut through the middle into two equal halves and the parts so hung on pivot pegs that the two halves would flop up, leaving an open space between them of about two inches. Underneath this wheel and on tracks was a car fitted with stalls. Muir would place his school books in the stalls in the order in which he wished to study them, lock the car and put the key where it was difficult to get, attach the clock to the machinery of the desk, climb on a high stool and await results. The clock would move the car to place and by a knocker arrangement underneath push a book up through the open space between the halves of the solid cog wheel, close down the halves and open out the book. Muir would study that book until time was up, when the halves of the wheel would flop up and drop the book in its stall. The car would then move to the next stall and repeat to the end of the list of books. Muir prearranged with the clock as to the time he should have to study each book, which arrangement was carried out to the letter. It was amusing to watch John sitting at that desk as if chained, working like a beaver against the clock and desk. The desk was built, he said, to make him more orderly and regular in his studies. He had a thermometer made of parts of an old, broken washboard, which was so sensitive that if one stood near it the index hand would quiver and move on the dial; also a miniature saw-mill with a self-setting log carriage—ingenious but not practical; also a little device for measuring the growth of plants, so delicate that when attached to a plant, one could see the hand move across the dial, measuring the growth from hour to hour; also other devices as ingenious and curious in construction and purpose as the ones described.

Muir's manner of life at the university was very simple. He boarded himself, as many of the students did in those days. His diet consisted chiefly of bread and molasses, graham mush and a baked potato now and then. Being in the good graces of Pat, he obtained a key to the basement where the old-fashioned wood furnaces were. Here he baked his potatoes in the hot ashes and boiled his mush on the hot coals. Muir was very poor at that time. He taught in the country schools in the Winter months, keeping up with his college classes in the meantime, and worked on farms in the Summer to procure necessary funds to carry him along in college.

For exercise he played wicket, walked and swam. Wicket was the only game then played at the university. It is much like cricket, except that the bails are six feet long, placed fifty feet apart on pegs about eight inches high. Four played the game, two at the ball and two at the bat. The ball was about the size of a modern football, but perfectly round and made of wound yarn covered with leather. The game furnished good exercise and was not so prolific of surgeon's bills and obituary notices as the modern game of football.

Muir's course of study, while irregular, corresponded closely to the then modern classical. He was a hard working student and very apt, and absorbed knowledge rapidly and accurately. The last two years of his course were devoted largely to chemistry and geology. He was acknowledged by common consent to be the most proficient chemical student in college. There were no laboratory facilities in the University at that time so Muir built a chemical laboratory in the room. With the multitude of things already there, the chemical laboratory clapped the climax. It would require a vivid imagination to picture conditions in that room after the laboratory was constructed and in full operation.

He was of a most gentle and loving disposition, a high-minded Christian gentleman, clean in thought and action. While he was not a very regular attendant at church, he read his Bible and said his prayers morning and evening of every day and he led the kind of life that all this imports. It must not be inferred, however, that he was austere and without any sense of humor, fun or frolic; far from it; he was as keen of a college prank as any of us.

Muir was not ambitious for wealth. What came to him of material prosperity was a mere incident of his life. It was his firm, unchanging religious faith, his all-absorbing love of man and beast and of nature generally that characterized the man and his life.

* By Charles E. Vroman in the *Wisconsin Alumni Magazine*.

The Children's Room in the Smithsonian Institution.

IN the Smithsonian Institution at Washington there is a room especially arranged for the children. It is not fitted up with swings, slides and seesaws, but with some of the wonders of nature; curious animals, birds, fishes, insects, plants, and rocks.

The room was designed and prepared under the personal direction of the late secretary, Dr. Samuel Pierpont Langley, whose interests were so human and broad that he took time from his other studies to direct the arrangement of this room for his "little clients," as he called them.

He believed in the saying of an early philosopher, that "knowledge begins in wonder," and realizing that some of his own researches were prompted in this way, he desired to interest children in science, so he based his grouping on the observing powers of children, and selected for exhibition the greatest and smallest, and the brightest and most inconspicuous specimens, all of which he labeled with their common English names. This little room for the children still remains intact, just as Dr. Langley planned it sixteen years ago.

In the center is an aquarium of brightly colored fishes and tiny turtles. The wall cases, which are all low so as to be within range of a child's vision, contain the different groups. The first, the "largest and smallest birds of prey," includes several birds ranging in size from the condor of the Andes to the tiny pygmy hawk. Next are the eagles and elf owls, followed by "some curious birds," all of which live up to their general label. Other birds are arranged together on account of their brilliant and gaudy coloration; one group consists of European birds, and another of common birds of the United States, one of the most interesting groups to the child who recognizes many of his feathered neighbors with surprising joy and ease. Then there is a beaver busy cutting a log; and here are also an attractive series of "pretty shells," a case of "strange insects," another of beautiful butterflies, followed by curious sponge and coral formations, and a case of "minerals and fossils."

Probably one of the most appealing exhibits is the series, labeled "How Creatures Hide," the children's room title for protective mimicry, which shows some of nature's devices for the protection of her living things.

Dr. Langley was exceedingly clear-sighted, and his efforts have no doubt instilled into the minds of many children the germ for a scientific education.

Recording Densimeter.

THIS is a well-designed recorder for checking up the density of a solution which is used in the industries, as the success of operations may depend on keeping the strength of a solution between certain limits. Workmen are likely to take greater pains when they know that a record diagram is being made for liquids such as acids or alkalis in chemical industries or the like. On the piping of the liquid is inserted a small tank through which the liquid flows. A small glass float is immersed, and it rises and falls with the varying density. The float hangs in such way as to connect by cord to a recorder device by which a tracer makes a pen record upon a drum.

High Explosives*

A Brief Summary of Their History, Manufacture and Use

By L. S. Marsh, Mem. Am. Chem. Soc.

In presenting the subject of high explosives I shall endeavor to give briefly the methods of manufacture, uses, and to a slight extent the historical side of the more important explosives.

While gunpowder or ordinary black powder is not generally classified with the modern high explosives, its discovery and development have been of so much importance in the general development of all explosives that a little time may be profitably devoted to it. Black powder was probably discovered by accident, and Friar Bacon, to whom is generally ascribed the discovery, did not, therefore, really invent gunpowder. It seems certain from such information as we have at our disposal that Friar Bacon about the year of 1250 had mixed up an experimental compound of some kind, the ingredients of which among others were saltpeter and sulphur. We can imagine the effect of igniting such a mixture, and if, perchance, the good Friar had rubbed some of the mixture in a mortar it is safe to assume that he was

Fig. 4.—Placing explosives to break a steel rail.

surprised at the results obtained by this simple though dangerous operation. Roger Bacon undoubtedly fulfilled the prophesy of Prometheus that, "in the latter day, a wonderous being would appear who should call forth flashes brighter than lightning and sounds louder than thunder."

Gunpowder was for years called "kraut" in Germany. For 500 years gunpowder remained the only explosive, and not until the year 1846 did there appear anything really new in the line of explosives. In this year, Schoenbein discovered nitro-cellulose, the basis of all smokeless powders, as well as of many modern products whose uses are more in the realm of peace than of war. In the year 1799 mercury fulminate was discovered by Howard, the use of which, however, as a filler for percussion caps was not commenced until 1815. The next important step in the development of explosives was the discovery by Sobrero in the year 1847 of that exceedingly important and highly explosive compound, nitroglycerine. Little use was made of nitroglycerine until the invention of dynamite because of the fact that nitroglycerine could not be handled and transported, in the liquid state, without very great danger. The first practical use of nitroglycerine was made during the construction of the Hoosac Tunnel, the nitroglycerine being transported to the work in a frozen condition. In 1875 Nobel discovered that an explosive composed of a mixture of collodion cotton and ordinary dynamite gave greatly increased results on explosion, this same investigator having discovered dynamite as we ordinarily understand the term, in the year 1867. Blasting gelatine, discovered by Nobel in 1875, and referred to above as the mixture of collodion cotton and dynamite, is probably the most powerful explosive, weight for weight at the present time, at least which can be used in any practical manner. Blasting gelatine owes its great explosive power to the fact that the excess of oxygen in the products of explosion of nitroglycerine supplies the deficiency in explosion of nitrocellulose, the carbon burning to carbon dioxide instead of partly to carbon monoxide, which additional chemical action results in the production of more heat and therefore greater volume of gas, and greatly increased force of explosion.

There are two general divisions in the classification of explosives, namely, explosive mixtures and explosive compounds. Explosive mixtures are mechanical mixtures containing various ingredients in the form of grains or finely pulverized material, these ingredients supplying a combustible and an oxygen carrier. As an example of an explosive mixture, gunpowder is the first one which comes to mind and is to all intents and purposes the most important of all explosive mixtures.

Explosive compounds are those substances which contain within the individual molecule the necessary substances or elements to produce an explosive wave when detonated or otherwise broken up. As an example of an explosive compound we may refer to many of the hydro carbons and compounds of organic origin, such as the nitro compounds of ether, acetone, phenol, glycerine, cellulose and a large number of other organic compounds.

Black gunpowder is one of the most common, and, from a practical standpoint, one of the most important of all explosives, and its manufacture while not without danger is, however, less liable to cause trouble in the process of combining the various ingredients than some of our other forms of explosives. Black powder, as made in this country, consists of potassium nitrate 75 parts, carbon in the form of charcoal 15 parts, and sulphur 10 parts. The first requisites in the manufacture of black powder is to obtain strictly pure materials, then the proper grinding and mixing of the three ingredients named above. The potassium nitrate supplies the oxygen necessary for the combustion of the carbon. In the manufacture of gunpowder the materials are first ground then sifted into grains of various sizes, after which the materials are weighed out in 50 pound lots. The mixing of these ingredients is accomplished by means of a rotating drum which is supplied with paddles traveling in an opposite direction to that of the drum itself. After the materials are thoroughly mixed in this manner they are taken to the incorporating mill which resembles the ordinary edge runner largely used in some of our older cement mills for the purpose of grinding slurry. The rollers of the incorporating mill weigh about 4 tons apiece and the charge of mixed materials is placed on the bed of the mill to a definite depth made necessary by the fact that if the layer is less than one fourth of an inch thick there is great danger of explosion, while if greater than one half inch in thickness the incorporation of the ingredients will not be satisfactory. The process of incorporating usually required from three to four hours and the product is known as mill cake, which is broken up into lumps of uniform size by machinery especially designed for this purpose. These lumps or particles are now made into press cake by means of hydraulic presses to further insure the complete homogeneity of the product, the press cake being again broken up and passed through sieves of different size mesh in order to produce powder grains of various sizes. The size of the powder grain is of great importance, as, upon the size of the grain depends the rapidity of combustion and, therefore, the shattering effect of the explosion.

Probably the most important explosive of modern times is gun cotton, this being largely used for filling shells and mines used in modern warfare. Gun cotton is probably the most easily handled and safest of all of our modern explosives. In order to gain an idea of the manufacture and composition of gun cotton we must start with the substance called cellulose. Cellulose is the skeleton left of the vegetable tissue after the substances whose functions rest entirely with the vital processes of the plant have been removed by chemical treatment. In order that you may observe the difference between nitrated and unnitrated cotton I am showing you a sample of cotton which has been nitrated for a period of 12 hours by being immersed in a solution of concentrated sulphuric and fuming nitric acids. The cotton used in this experiment was ordinary cotton candle wicking, and you will note that upon applying a flame to the unnitrated cotton it will burn slowly as is usually the case with such material. Applying the flame to the sample of nitrated cotton results in a quick flash with no remaining ash after combustion. The rate of propagation of the explosion in gun cotton is somewhere between 17,000 and 21,000 feet per second.

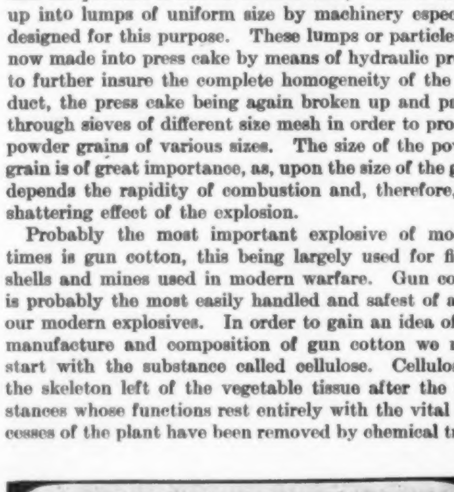


Fig. 5.—Explosion of charge shown in Fig. 4.

In the manufacture of gun cotton old rags and waste from cotton spinning mills are generally used, which require very careful cleansing and drying before being subjected to the nitrating process. The cleansing is accomplished by treating the cotton with a strong solution of caustic potash and then washing with running

Fig. 6.—Result of explosion shown in Fig. 5.

water until all traces of the caustic are removed. The material thus prepared is dried and then weighed out in batches of 16 pounds each and placed in the nitrating machine. The nitrating machine resembles somewhat the ordinary centrifugal used in the sugar mill and is so arranged that the acids used in nitrating may be rapidly removed and water allowed to run in in order to commence the washing at the very earliest possible moment after the action of the acids has been completed. During the process of nitration the cotton increases in bulk and weight, the 16 pounds weighing when nitrated about 25 pounds. In order to remove all traces of acids from the nitrated cotton, washing is continued for several hours in running water, after which the nitrated cotton goes to the hydraulic press for the removal of excess water. If the gun cotton is to be stored for any great length of time, about 40 per cent of water is left in it in order that there may be no possibility of accidental explosion as wet gun cotton is perfectly safe under all ordinary conditions. Our modern smokeless powders are made by treating gun cotton in such a way as to produce what are known as colloids. After cotton fiber has been treated with nitric acid and sulphuric acids, as in the process of nitration, it possesses a property which it did not have before nitration and that is its solubility in certain substances, most important of which are acetone and a mixture of alcohol and ether. Gun cotton dissolved in these solvents will give a light amber colored solution which, upon evaporation, will yield solids more or less viscous in their nature, the viscosity depending upon the amount of solvent left in the mixture. This resulting compound is called a colloid and is the substance used in the manufacture of smokeless powder. In the practical manufacture, on a large scale, of smokeless powders nitrated cotton is run through a machine which shreds it into small particles very much resembling paper pulp as in the process of paper manufacture. Chemical control is maintained during the process of shredding and washing in order to ascertain the presence of free acids in the mass. Gun cotton must not be permitted to retain any of the acids used in the process of nitration as they would cause decomposition and consequent accidental explosion. After the gun cotton has been thoroughly shredded and resembles bread dough it is placed in what is called a stuff chest in the interior of which revolves an endless screw which forces the cotton out through an opening at the top. The gun cotton as it is now prepared contains about 40 per cent of water and in order to remove this excess water and prepare the cotton for the colloiding process it is put through a

* Reproduced by courtesy of the *Journal* of the Western Society of Engineers.

Fig. 7.—This shows effect of a charge placed without tamping.

hydraulic press and a large part of the water removed by pressure. The pressure cannot be continued sufficiently, however, to remove all of the water and alcohol is permitted to run through the top of the cylinder containing the cotton, thus taking out all of the water by solution in alcohol. Practically all of the alcohol is pressed out of the cotton which then goes to another press and is treated with ether thus completing the process of colloidization. The colloided cotton is passed through dies by means of an endless screw revolving in a drum, these dies being arranged with needles which give perforations in the resulting rope or rod of smokeless powder. These rods are of varying diameters and are cut into sections or grains by means of bronze knives. As in the case of ordinary gunpowder the size of the grain determines the rapidity of combustion, and for large caliber guns smokeless powder may be produced in the form of sticks resembling walking canes which are made up into bundles to form cartridges.

The manufacture of nitroglycerine is very similar to that of gun cotton with the exception that the substance to be nitrated is glycerine in the place of cellulose. Nitric and sulphuric acids are used for nitrating glycerine but a very careful watch has to be kept of the process in order to prevent the occurrence of disastrous explosions due to the decomposition of the glycerine and consequent rise in temperature of the mixture. The nitrating of glycerine usually requires about one half hour after which the treated glycerine is run into tanks filled with

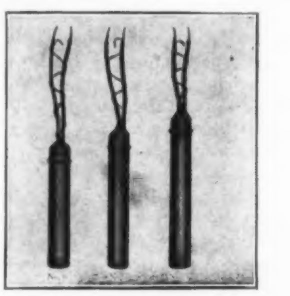


Fig. 1.—Electric exploders.

water where it sinks to the bottom and is drawn off for further purification.

Nitroglycerine, as such, is not used to any great extent at the present time but is the basis of a large majority of the dynamites now on the market. Ordinary dynamite consists of some absorbent material such as infusorial earth, otherwise known as kieselguhr, which is permitted to absorb the nitroglycerine, the amount of this absorption depending upon the strength of the dynamite desired. Dynamites are graded according to the percentage of nitroglycerine which they contain, as for example, 60 per cent dynamite contains 60 per cent by weight of nitroglycerine. Some of the modern dynamites contain in addition to nitroglycerine, other substances which supply an excess of oxygen and thus increase the violence of the explosion.

I have already mentioned the discovery of blasting gelatine and I would briefly state here that blasting gelatine consists of about 90 per cent nitroglycerine and 10 per cent nitrocellulose, the two substances being mixed by means of wooden paddles in a large tank or vat, and finally kneaded with the hands like bread dough until a mass, having a smooth even consistency, is obtained, the resulting product resembling a jelly-like substance, soft enough to be easily cut with a knife. This mass is forced through a die as in the manufacture of smokeless powder and the rope or cable is cut by means of a bronze knife into the desired lengths and wrapped in paraffine paper to form the completed dynamite stick.

Just as we have explosives of various methods of action, so, naturally, we have three classifications of explosive actions, as follows: Explosions of low order, otherwise combustions or progressive explosions. Detonations, or explosions of high order, and fulminations, which are explosions extremely brusque in their nature.

Among those explosives which give progressive explosions or combustions we classify the charcoal powders and the nitrocellulose powders. Explosions of these substances are differentiated from explosions of high order or detonations by the fact that they take an appreciable length of time for the completion of explosive action, which is in fact nothing more or less than a form of rapid combustion. A train of black powder, a hundred or more feet in length, will require an appreciable length of time for the propagation of the explosive wave if ignited at one end, the length of time required for the combustion to be carried throughout the length of the train depending upon the size of grains of which the powder is made, the larger the grains the slower the rate of combustion.

Among the detonating explosives we should note gun cotton, nitroglycerine, dynamites and all picric acid compounds as well as a large number of nitro compounds and substances of organic derivation. The difference in action between detonating explosives and explosives of low order is due to the fact that in explosions of high order the result is brought about by a rupturing of the molecular bonds which hold the substance together, this disrupting action being started by a proper detonating explosive, usually with an electric or time fuse. In order that explosives may be properly handled and used to advantage we require exploders or detonators. Fig. 1 shows an exterior view of three sizes of electric exploders largely used for this work. These exploders are copper shells into which is placed a suitable amount of detonating substance, usually fulminate of mercury, the cap being rated according to the number of grains of mercury fulminate which it contains. Fig. 2 shows a sectional view of one of these electric caps with the leading in wires *CC*, the platinum igniting wire *E*, and the mercury fulminate *B*. Current for the ignition of these exploders may be obtained from the regulation blasting magneto, from storage batteries, or from any other suitable source of electric current.

It often becomes necessary in the use of explosives to figure properly the amount of explosives required to do a certain thing, and while it is not possible to figure with extreme nicety the amount of explosives required for any purpose we have rules which are sufficiently close for practical work, and in order to understand these rules and properly apply them we must first consider what is known as the line of resistance. In Cut 1, Fig. 3, is shown a charge of dynamite represented by the black portion at *C*. The effect of the explosive wave is at right angles to the center of the charge, and this line is called the line of resistance. In Fig. 1, above referred

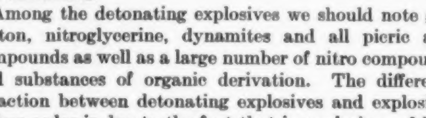


Fig. 2.—Section of electric exploder.

to, the probable crater formed by the explosion will be *ACB*. The angle at which the bore hole should be driven depends upon the nature of the substance to be blasted. In Cut. 2, Fig. 3, is shown a wall having two parallel surfaces and also the probable crater *ACB*. Cut 3 represents a horizontal undercut surface, which would require that the bore hole should be driven at a point opposite the angle at *F*. In a case of this kind the bore hole should not be driven all the way through but should be at least three fourths the distance *AD* in order that the blast should not blow out a small crater as *CFB*. As the line of resistance is the longest line at right angles from the charge in the direction explosive effect is to be carried, we may approximate closely to the amount of explosive required by the following formula: Let C equal total charge in ounces, LR line of resistance in feet, K equal coefficient of resistance of material to be blasted: then C will equal $k\,(LR)^3$. If the value of k is not known it may be taken as 0.2. Tables are available giving the coefficients of resistance for various materials.

In preparing a charge of dynamite for blasting the matter of tamping is of great importance, as a charge which is not properly tamped will not give the maximum explosive effect. Fig. 4 shows a charge placed against the web of a steel rail with a small amount of tamping; in this instance wet clay was used. The explosion of this charge is shown in Fig. 5 and the effect of the explosion in Fig. 6. It is to be noted that a large piece of the rail was blown out, in this case the piece being about 18 inches in length, and it was blown for a distance of one fourth of a mile, the charge being two sticks or 1.2 pounds of 60 per cent dynamite. Fig. 7 shows the effect of the same weight of dynamite placed against the web of the rail without any tamping, the rail is bent but the damage is much less than in the former case. Fig. 8

Fig. 8.—Effect of dynamite on a tree.

shows the shattering effect of a charge of four sticks or 2.4 pounds of 60 per cent dynamite on a large tree, which was blown entirely down by the explosion of this charge. The diameter of this tree was about 24 inches and the dynamite charge was placed in bore holes extending nearly to the heart of the tree, equally spaced about the tree.

In the handling of dynamite and all other explosives precaution should be the watchword, and familiarity with these dangerous substances should never be permitted to obscure one's ideas of safety. If there is any place where the "safety first" idea should be used first, last and all the time it is in the handling of explosives. Do not attempt to use frozen dynamite, and do not thaw dynamite around an open fire. I am well aware that this latter practice is very common and that apparently accidents are not numerous, but when an accident does happen it is sufficiently terrible to warn anyone against the practice. There are on the market suitable devices for thawing dynamite which are safe and inexpensive, and it is foolhardiness to attempt this operation without the protection afforded by a properly designated apparatus. Do not store dynamite and detonators close together. Keep them separated as the explosion of a detonator may set up an explosive wave sufficient to detonate a large amount of dynamite or other explosive. Do not tamp dynamite in bore holes with metal tampers

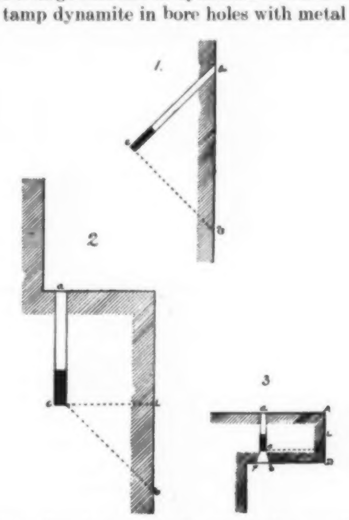


Fig. 3.—Showing methods of placing explosives and the probable effects.

—use wood and wood only. Do not be in too much of a hurry to investigate the causes of a misfire. Better wait and go on with other work until it is certain there will be no explosion of the charge. In spite of all directions that might be given for the careful handling of explosives there will always be found the man who will persist in crimping caps on to fuses with his teeth until he does this once too often. Crimpers are furnished for the purpose of attaching caps to fuse leads and there can be no excuse for using your teeth or a hammer.

Practically all of the explosives which are on the market at the present time, are safe if handled in a proper manner, and just as unsafe when injudiciously handled.

Reinforced Concrete in Siam

The King's Palace at Bangkok is the first application of this system here, and reinforced concrete enters extensively into this handsome structure, the walls being covered profusely with marble of various colors. In the region near the palace are several bridges over the river, the first one lying about 2 miles from the city, and here reinforced concrete is largely used. Such bridges have a single arch of 26 to 50 feet span and have a pleasing decoration in relief tiles, or, in other cases, in concrete. Four bridges of the kind are now erected.

Is the Organism a Thermodynamic Mechanism?—II*

A Consideration of Certain Organic and Inorganic Systems in Relation to Physical Laws

By James Johnstone, D.Sc., University, Liverpool

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WHAT this discussion leads up to is the consideration of the second law of thermodynamics as a probability only. The law states that inorganic phenomena tend in one way—toward increase of entropy. But the sign of the law may be changed, that is, events may also conceivably take place in such a way as to lead to diminution of entropy. It is more probable that entropy increases than that it should diminish.

Unless we postulate that the entire universe is passing from an initial determined state toward a final definitive state, we cannot regard the second law of thermodynamics, as it is usually stated, as true.

We can define an organism as an autonomous physico-chemical system; possessing specific form; maintaining its specific form in the midst of an environment which undergoes change, by active, compensatory adaptations of its functioning; capable of indefinite growth by accretion and dissociation (reproduction); and effecting energy-transformations without cessation (for in the general sense the organism does not die). The definition withstands criticism. We cannot here defend it in detail, and all we are immediately concerned with is the conception of the organism as a system *in which compensatory energy-transformations proceed*. We can show that it conforms to the two laws of thermodynamics, but the second law must be regarded as having a double sign.

The body of a plant or animal is a system conforming strictly to the law of conservation.[1] If the weight of an animal remains constant, there is an exact balance between the mass of the ingesta and that of the egesta. If the energy-values of ingesta and egesta be determined, a difference will be found; that is, the energy value of the ingesta is greater than that of the egesta. But the difference will be represented by the value of the energy of the mechanical work done by the animal, by the heat conducted away from its body by conduction and radiation, and by the heat of the egesta. The animal body is therefore a machine that transforms energy just as a heat-engine does, with the limitation that we have suggested, of the second law of energetics.

It is a much more "efficient" machine than those of thermodynamics, if we like to put the difference in this way. But it is hardly accurate to speak of the efficiency of the organic mechanism in the same way as an engineer speaks of the efficiency of a heat-engine; for the animal efficiency is an adaptation. The efficiency of an overfed, sedentary man is only a small fraction of the efficiency of a soldier in perfect health and in "hard" training. The fraction of the potential energy of the food which transforms to the kinetic energy of bodily movements obviously depends on the "will" of the animal—it is an adaptation to the circumstances in which the animal places itself.

There is a certain loss in the transformation of chemical energy into mechanical work in an inorganic system. Some fraction of this energy is dissipated as heat; a large fraction in the case of a heat-engine, and a smaller fraction in the case where chemical energy transforms directly to electrical energy, and then the latter to mechanical energy. We cannot, however, be quite sure that any part of the potential energy of the food is so dissipated in the metabolism of the perfectly healthy animal. Heat is certainly radiated away from the body of a mammal, but we must regard heat-production as a definite, purposeful activity in such an organism. It maintains its body at a certain constant temperature, which is that temperature at which its metabolism proceeds with the greatest advantage to itself. The organic system, like the inorganic one, conforms to van't Hoff's law, and it is obviously an advantage that the rate of chemical change should be independent of the temperature of the environment. Constant bodily temperature is therefore a compensatory adaptation. The warm-blooded animal is, however, the exception, for the majority are cold-blooded; that is, their temperature is identical with, or approximates very closely to, that of their immediate environment. In such animals the potential energy of the compounds taken as food transforms into the kinetic energy of the movements of the body without passing through the form of heat. Further, since it is very difficult, or impossible to demonstrate by exact calorimetric experiments, any heat production in a cold-blooded animal, we cannot say that energy is dissipated in its transformations.

In disease, or in imperfect functioning, there is, of course, more or less wasteful heat production. But we cannot demonstrate that there is an inevitable, fairly large dissipation of energy in the organic system, and so we cannot apply to it the second law of thermodynamics with all the strictness in which it applies to inorganic systems. Certainly it is misleading to compare the "animal machine" with the heat-engines of physics. The animal organism is a system in which energy falls from a state of high, to a state of low potential, as in, say, the Carnot engine. Some part of the energy of the heat-engine transforms to mechanical energy—does work against resistance—and some part is dissipated and becomes unavailable. In the animal, also, potential energy transforms to mechanical energy, but it certainly has not been shown that any large part of the potential energy taken in becomes truly dissipated, in the cold-blooded animal at all events.

This type of metabolism, the katabolic type, characterizes the animal, but not the plant. The essential difference between typical animal and typical plant is that the former possesses a sensori-motor system while the latter does not. Energy of the available form is made use of by the animal (and the heat-engine) and transforms to the kinetic energy of moving bodies. Energy of radiation is said to be made use of by the typical plant organism; but it transforms, not to kinetic energy of the parts of the plant, but to potential chemical energy. The typical plant energy-transformations are to be compared with the exceptional endothermic transformations of inorganic systems.

The salient character of plant metabolism is the synthesis of carbohydrate and proteid from inorganic compounds. Water and carbon dioxide react together in such a way as to form a sugar; that is, the elements of the latter are those which have been taken into the plant system as water and carbon dioxide. These compounds possess far less intrinsic energy than does the sugar which is formed from them, so that the plant must have some source of available energy to draw upon in effecting the synthesis. This source is radiation. In the absence of light chlorophyll is not formed, and in the absence of chlorophyll sugar is not synthesized from water and carbon dioxide. More energy is represented by the radiation falling on the surface of the green leaf in unit time than is represented by the energy-difference between the sugar which is formed in unit time, and the carbon dioxide and water which are the initial phase in the transformation. Formaldehyde can be synthesized from water and carbon dioxide, and it is conceivable that formaldehyde may be "polymerized" to form a sugar. There is a certain functionality between the intensity of the incident light, the concentration of carbon dioxide round the chloroplastids, and the quantity of carbo-hydrate synthesized. It is thus probable that the formation of starch in the plant organism is a "photosynthetic" process, and that the requisite energy is obtained from that of light radiation.

But, it must be urged, repeated investigation has failed to show clearly that the radiation is the actual source of the increase of available energy due to the life processes of the plant organism. Radiation falling on an inorganic surface almost always transforms into low-temperature heat, unavailable for such a chemical transformation as that of water and carbon dioxide into carbohydrate. Further, precisely the same synthesis is effected by certain species of bacteria. Nitrifying organisms can form carbohydrate and proteid from a medium containing an ammonia salt, water, atmospheric carbon dioxide, and traces of essential mineral substances, *in the absence of light radiation*. A general theory of organic syntheses must also include these transformations, and must not regard as indispensable a source of available energy in the form of radiation.

Let us consider the system, water, carbon dioxide, and radiation as an inorganic one. If it can undergo an irreversible change it will do so, when it will attain a condition of stability. If it cannot undergo an irreversible change it will remain stable. It does not, of course, change; that is, *of itself*. The system carbon dioxide, water, and light radiation is not susceptible of transformation into the system carbohydrate. Neither will water and carbon dioxide undergo spontaneous change to form acetylene. But water can be decomposed so as to obtain hydrogen and oxygen, and carbon dioxide can be decomposed so as to obtain elementary carbon. Acetylene can then be synthesized from its elements. But obviously the synthesis is only possible when we couple the systems, incapable of themselves of further change, with other systems which do undergo change, in the course of which available energy is evolved. That is to say, we can reverse otherwise irreversible energy-changes if to the system which has attained stability we can couple a compensatory energy-transformation. Assuming, then, that the formation of sugar in the green plant is a physico-chemical reaction dependent on the transformation of the energy of radiation, we arrive at the conclusion that the living plant-cells themselves are not part of the physico-chemical system in which the potential chemical energy of sugar is being accumulated, but they are the agency which effects the compensatory energy-transformation.

Reverting now to the essential distinction between animal and plant we recall that the former is a physico-chemical system, in which potential energy passes into kinetic energy; while in the latter there is an accumulation of potential energy. In organic systems in which potential passes into kinetic energy the tendency is always the same, that is, the final form of the transforming energy is low-temperature heat, which becoming uniformly distributed throughout its environment also becomes dissipated. In organic systems in which potential energy passes into the kinetic form, that is, in the animal, there is no such necessary tendency, for the sensori-motor system is such that the kinetic energy resulting from the processes of metabolism can be directed. It *may* at once be truly dissipated, but it may also be transformed into available energy. An animal may uselessly dissipate its energy, with no other result than to cause mechanical friction; but it may also so use it as to create differences of potential, whereby a part, at least, of the energy transformed remains available for further change. In inorganic systems in which potential energy accumulates, that is, in the plant organism, the same tendency is carried much further, inasmuch as stable chemical compounds of high energy-value are formed as the result of the life-process. Thus in organic systems generally the tendency of their energy-transformations is opposed to that which characterizes inorganic systems. In the latter entropy is continually augmented; in the former entropy-augmentation is arrested.

Further, the organism *is that which affects compensatory energy-transformations;* and the more we think of it in this way the more clearly do we appreciate the distinction between the organic and the inorganic system. The green plant with its environment is the theater of a twofold energy-transformation; on the one hand certain parts of the whole transform irreversibly into the compounds water and carbon dioxide, while, on the other hand, part, that is, the energy of radiation, transforms in such a way as to reverse the tendency to dissipation which is the result of the katabolism of the plant or its associated animal life. The plant itself, that is, something which is neither the metabolizing proteid and carbohydrate, nor the carbon dioxide and water, couples together the energy of radiation with the transformed carbon dioxide and water so as to form carbohydrate. This is essentially what occurs in the synthesis, with absorption of available energy, of a chemical compound in the conditions of the laboratory. Some substance which has never been found apart from the tissues of a plant or animal is formed from the inorganic materials by the chemist who sets up a compensatory transformation. Clearly such syntheses do not prove that there is no distinction between the organic and inorganic, since they are effected by precisely the same means as that by which they are brought about in the organism. Of themselves they do not occur free in inorganic nature; they occur only as the result of *direction* conferred on physico-chemical reactions by the intelligence of the experimentalist—that is, by life.

The organism therefore exhibits *tendency* which is opposed to the direction taken by inorganic processes. But the latter is, as we have seen by considering Boltzmann's example of a physically changing gas, not necessarily always the same. It is highly probable that any physical change whatever will proceed as the second

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*From *Science Progress*.

[1] That is, the organism considered like other physico-chemical systems as an object in space, objectively considered. Subjectively some things—dreams, visions, some memories, hallucinations—are not conserved. We get over this difficulty by saying that the things that are not conserved, though they possess existence, are unreal. The things that are real are the things that are conserved.

law of thermodynamics indicates, that is, in such a way that entropy will be augmented. But it may proceed otherwise: two gases at different temperatures, and in thermal contact with each other, will most probably mix so that in a short time the temperature of the mixture will everywhere be the same. The change is irreversible, we say, in the sense that it is highly improbable that it will reverse of itself; but it *may* reverse, and there *are* regions in the whole mass of gas where the temperature is higher than in adjacent regions. Yet the probability of a reversible change is infinitesimally small, and the dimensions of the regions in which the temperature departs from uniformity are also infinitesimally small.

The universe which is physically active is, both in its dimensions and its duration, very great. But the material universe that we know occupies only an infinitesimally small part of space: probably the stars that we know, that is, those which radiate light, are only a small fraction of the whole material universe. To say this is the same thing as to say that it is highly improbable that any part of the entire universe is physically active —has been the theatre of a restoration of available energy, or a reversal in sign of the second law of thermodynamics. But life also is highly improbable. The total mass of organized substance on our earth is infinitesimally small in comparison with the mass of the globe. The mass of nitrogen in the chemically combined form is an infinitesimally small part of the total nitrogen of the atmosphere. Vegetation, rich as it may be on some parts of the earth, is entirely absent over other large areas, and is anywhere only a film of almost inconceivable tenuity in comparison with the bulk of the planet. If living substance is the expression of a reversal in sign of the second law of energetics, its probability of occurrence is of much the same order as that which we have already indicated in relation to physical changes.

The reader may now see the cloven hoof of Bergsonism in the above argument. Life is that which sets itself against, and tries to arrest the general tendency to inertia. In his distrust of metaphysics he may attach slight value to such a view of the organism, but, approached from the standpoint of the second law of thermodynamics as only a probability, the Bergsonian speculation may not appear to be so fantastic after all. A theory of the organism must, it seems to us, take account of the second law of energetics as having a double sign. It may be, of course, that the activities of the organism are capable of reduction to chemical and physical processes, all of which are to be regarded as special cases of the second law—in that event biology is only a department of physical chemistry, and our conception of life must be a mechanistic one. But so long as physiology fails to provide physico-chemical explanations of vital processes, and so long as another physics and chemistry than that of the second law is conceivable, then a real science of biology may be possible; and to insist on a mechanistic conception of the organism is only to dogmatize.

Problems of Airship Design and Construction*

The problem of the airship falls naturally into three parts, concerned with flotation, propulsion and steering respectively. The best results in any of these three branches are to a great extent antagonistic to similar success in one or both of the other two. For instance, flotation, which is purely a displacement problem at bottom, demands that the displacement body should have the greatest volume for the least superficies, i. e., that it should be spherical. Propulsion, on the other hand, demands that the body be of the shape having least head-resistance, i. e., of long fish-shape. Steering with which is linked dynamic stability, demands that large fins and control surfaces be affixed to the body, which otherwise would set itself broadside on to the relative current caused by its forward movement. These auxiliary surfaces add to the weight, that is, oppose flotation and add to the head-resistance, thus opposing propulsion. Again, the displacement body must of necessity consist mainly of a gas lighter than air. All the light gases are highly inflammable (or if not have some other disadvantage), and consequently are dangerous in proximity to an internal-combustion motor, such as is universally used for propulsion, as being the only motor with a good ratio of power to weight. Therefore the motor must not be placed too close to the gas-container, and in consequence it is difficult to enclose all the parts of the airship in a single "streamline" body of least resistance, and the head-resistance and weight are thus both increased considerably, opposing propulsion and flotation.

The above list of incompatibilities might be extended considerably, as every airship designer knows to his cost. It is not to be wondered at, therefore, that airship design is in so fluid and embryo a condition that the future of the airship is looked upon as extremely dubious in many quarters. The fact, however, that so much progress has been made in face of stupendous difficulties is a happy augury for the future of the airship, especially as many of the difficulties met with are due mainly to the fact that airships are at present small, and they will disappear as soon as experience and growing confidence enable large and larger vessels to be built.

To deal with the displacement body, or lifting unit first. The lift obtainable is, of course, directly proportional to the weight of air displaced and inversely proportional to the weight of the displacement body in itself. Roughly, 13 cubic feet of air at sea-level and normal temperature weigh 1 pound, so that a lifting unit displacing that volume would lift 1 pound minus its own weight. Consequently, if the lifting unit consisted of "nothing shut up in a box" as the schoolboy's definition of a vacuum runs, only the weight of the box would have to be deducted from the gross lift obtainable. As no light vacuum-container could maintain its shape against atmospheric pressure, however, a gas must be used to keep the displacement body distended by its expansive properties. The gas universally used for airships is hydrogen. This weighs about one-fifteenth of unit volume of air, so that only one-fifteenth gross lift is lost by its use. The possibilities of getting wonderfully enhanced lift by new gases, lighter than hydrogen, are thus seen to be illusory.

Coal gas was long used (and still is) for ordinary spherical balloons, as being cheaper and more available than hydrogen, but being about ten times as heavy as hydrogen, is comparatively useless for airships. Ammonia vapor has been suggested for airships, as being non-inflammable, but is about eight times as heavy as hydrogen and of a destructive character to metal, etc. The provision of a stable non-inflammable light gaseous mixture would solve so many practical difficulties in the construction of airships that many thousands of pounds could profitably be expended in research on this problem. Failing this provision, all precautions must be taken to prevent fire, or to minimize its effects on board airships.

Hydrogen being non-explosive apart from oxygen, can be isolated in containers jacketed with an inert gas and thus rendered harmless. The division of the displacement body of an airship into compartments is desirable from this and other points of view. For example, a large volume of gas in a thin fabric container is prone to surge about and strain the container when in motion. Compartments prevent this and also localize leakage due to rupture of any part of the container.

The type of airship in which this principle is carried farthest is the rigid type (Zeppelin) in which the displacement body consists of seventeen or eighteen separate gas-containers, set in a rigid cylindrical framework, like peas in a pod. The chief advantages of the rigid framework are (i) that the actual gas-containers are relieved of strain and are (ii) protected from the influence of the weather. The disadvantages are (i) the loss of gross lift due to the weight of the framework, and (ii) the fact that the airship cannot be folded up for transport or storage, and must consequently be housed in a large and expensive shed.

The gross lift of a large Zeppelin is about twenty-five tons, of which about twenty tons are absorbed by the framework, engines, etc. This gives a net lift of only about one-fifth of the gross lift, a figure that could be much improved by making the vessel larger. This net lift has to account for crew, etc., so that not more than two tons of explosives could be carried, and this only at a low altitude. Naturally, other things being equal, the weight of the framework, etc., of a small airship is a larger proportion of the gross lift than the corresponding weight of a large airship.

In that type of airship in which the walls of the gas-container are themselves the "framework" of the displacement body (the "non-rigid" type), much weight is saved, but disadvantages come in that strains on the fabric affect its gas-tightness, which is also much affected by action of sun and other influences.

Again, the attachment of the car (containing the engines, etc.) by wire ropes to the container is worked out on the assumption that the gas-container will retain its shape. This end is attained in single gas-containers by having a bag of air (the "ballonet") inside the container, into which is pumped air under pressure, to maintain the full volume and shape of the envelope. If, however, compartments are to be used in the container, some means of equalizing their pressures, even if one be ruptured must be devised, otherwise the shape will be distorted. This is no easy task.

The non-rigid type has the great advantage of being quickly deflatable for transport packed up. Examples of this type are the Parseval and Astra-Torres, in which latter ship an ingenious system of suspension greatly strengthens the gas-container.

The "semi-rigid" type has some of the advantages and the disadvantages of both the other types. Examples are the Forlanini (Italian) and Astra XIII. (Russian).

The material of which gas-containers are usually constructed is made of layers of cotton fabric cemented to layers of rubber. In order to intercept the blue (actinic) rays of light that "rot" the rubber very quickly and make it porous to the gas, the fabric is colored yellow. Goldbeater's skin makes a very gas-tight container, but untreated is affected by rain, which is absorbed, and by its weight decreases the net lift. This disadvantage applies to untreated fabrics, which are therefore usually varnished with an aluminum varnish, thus preventing water absorption and promoting gas-tightness. Fabric impregnated with gelatine, rendered flexible by added glycerine, and insoluble by formaldehyde, has given promising results. Oiled silk is very gas-tight but seams are troublesome. Very much research is still required into the question of fabrics.

Propulsion demands a power plant and means for obtaining a reaction from the air. The ratio of power installed to weight lifted has been steadily rising both in airships and aeroplanes. The first Zeppelin airship (1900) weighed 10,200 kilograms and the motors were two, totaling 32 horse-power. Zeppelin III. (1906) lifted 12,575 kilograms and the motors (2) totaled 130 horse-power. The "L1" (marine) of 1913 lifted about 28,000 kilograms and the motors totaled 720 horse-power. As an indication of the performances that may be expected from airships in years to come, we may note the proportion of power to weight lifted in the last vessel as one horse-power to every 80 pounds lifted. The speed attained is 50 miles an hour. In the case of an aeroplane doing 90 miles an hour or so, the weight lifted is only about 15 pounds per horse-power.

Screw propellers are universally used for airships, and are often of wood. They are usually placed at the sides of the gas-container in rigid vessels and below it in non-rigid vessels. Much research is needed as to the best position for propellers relatively to the body to which they are attached.

A strong reason for increasing the power of airships is that by so doing a large amount of lift can be obtained by the dynamic action of the large control surfaces, which, by directing the airship's nose up, are able to give it a very fast rate of rise, much quicker than that of aeroplanes.

The maximum height attained by airships is somewhat more than 10,000 feet (Zeppelin and Italian). Aeroplanes have ascended twice as high and ordinary balloons three times as high. To attain 10,000 feet high an airship must sacrifice much ballast and gas, so that it cannot voyage for its longest period at a great height. Zeppelins are claimed to be capable of holding the air for three days, but not at full speed or height. There is no advantage in going very high (except for military reasons), and under 3,000 feet would be a usual zone in which to operate were it not for anti-aircraft measures. Some day, when the airship is better developed, it may pay to go to great heights in order to obtain the advantage of lessened resistance to advancement due to the tenuity of the air.

As regards steering and stability, it may be said at once that most airships steer clumsily and require large spaces in which to maneuver. Our little non-rigid vessels have been specially developed for handiness in our much wooded country, but Zeppelins are craft for vast open spaces. The dynamic stability of an airship is a complicated matter to work out. Besides ordinary pitching and rolling there are added effects due to surging of the gas and distortion of the gas-container. Propellers also complicate the stability question. Large control surfaces are essential, sticking well out from the body, to avoid its "wash."

* From *Nature.*

The Wood Preserving Industry

A report issued by the American Wood Preservers' Association states that ninety-three wood preserving plants in 1913 consumed over 108,000,000 gallons of creosote oil, 26,000,000 pounds of dry zinc chloride, and nearly 4,000,000 gallons of other liquid preservatives. With these the plants treated over 153,000,000 cubic feet of timber, or about 23 per cent more than in 1912. Impregnation of wood with oils and chemicals to increase its resistance to decay and insect attack, according to the report, is an industry which has become important in the United States only in recent years. In Great Britain and most European countries practically every wooden sleeper and telephone or telegraph pole receives preservative treatment. In the United States less than 30 per cent of the 135,000,000 sleepers annually consumed are treated, and the proper treatment of an annual consumption of 4,000,000 poles may be said to have scarcely commenced.

Construction of a Vibrating Rectifier.

A Useful Apparatus for Charging Automobile Ignition Batteries

By Charles Fraasa

The following article gives a design for a vibrating rectifier similar to a type which was recently placed on the market both here and abroad for rectifying alternating current to charge automobile ignition batteries, etc.

The construction of the rectifier and the electrical connections are shown in Figs. 1 and 2, respectively.

The rectifier consists of a small step-down transformer and a vibrating polarized armature carrying contacts by means of which the reduced voltage of the transformer is connected with the direct-current circuit at the proper moment to obtain a pulsating direct current.

Referring to Fig. 1, the armature *A* is a piece of soft iron pivoted at its center *B* and free to vibrate in the coils *C*. These coils *C* are wound in the same direction and are excited from the direct current side of the rectifier, giving the armature a definite and constant polarity. The armature carries two contacts, *D* and *E*, and the spring contacts, *F* and *G*.

The magnet *H* has a soft iron core upon which two coils *I* are wound. These coils are excited by alternating current and are wound in opposite directions so as to produce similar poles on the ends during each alternation, i. e., both ends will be *N-N* or *S-S*, at the same instant.

Fig. 2 shows the connections and will illustrate the following explanation of the operation of the converter. The primary terminals, *P*1 and *P*2, of the step-down transformer are connected to the alternating current mains. The secondary terminals of the transformer connect to *S*1, *S*2, and *S*3 of the converter.

During one alternation (half cycle) let us assume that the current flows through the transformer secondary in the direction *S*1 to *S*3. The ends of magnet *H* will both be north poles. If a storage battery to be

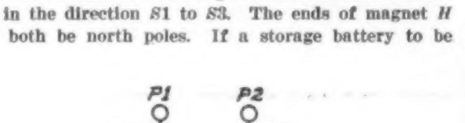

Fig. 2.—Electrical connections of rectifier.

charged is connected to the direct-current terminals, connecting the negative terminal to *D*1 and the positive to *D*2, the current flowing in the coils *C* will magnetize the armature *A*, producing the north and south poles on the armature as shown (Fig 2).

Since both stationary magnet ends are *N* poles, the *N* pole of the armature will be repelled and the *S* pole end attracted, closing the circuit between the contacts *D* and *J*, and opening the circuit between contacts *E* and *K*; the spring contacts *F* and *G* will, however, still bear against contacts *L* and *M*. The current from the transformer secondary will then flow through the circuit *S*1, *S*2, *D*2 through the battery to *D*1, *L*, *G*, *D*, *J* and back to *S*1.

During the second alternation the secondary transformer current will flow in the direction *S*3 to *S*1.

The current flowing in the opposite direction in the stationary magnet coils *I* will produce *S* poles on the magnet *H*, the polarity of the armature remaining the same, since it is excited by direct current. The *S* poles on magnet *H* will attract the *N* end of the armature and repel the *S* end and the armature will swing over, breaking the circuit at *D* and *J* and closing the circuit at *E* and *K*. During this alternation, the current in the transformer secondary flows in the direction *S*3, *S*2, *S*1, and will at this instant flow in the circuit *S*3, *S*2, *D*2 through the battery to *D*1, *M*, *F*, *E*, *K* and back to *S*3.

From the foregoing it is evident that as the current supply alternates the armature rapidly vibrates, closing first one contact and then the other, at the proper instant to produce a pulsating direct current.

The rectifier described below was designed for operation on 60 cycle, 110 volt alternating-current circuits. The direct-current voltage will be about 7 or 8 volts, and the safe load about 8 amperes

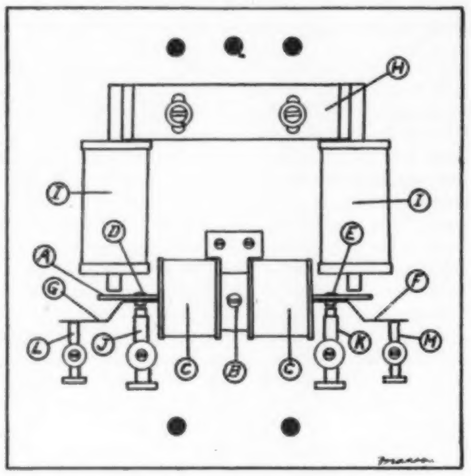

Fig. 1.—Plan of vibrating rectifier.

The alternating-current magnet *H*, Figs. 1 and 2 dimensioned in Fig. 3, consists of a yoke strip *O* and two cores *P*. These pieces should be cut from some soft strip iron and drilled and tapped for small machine screws which hold the parts together. Referring to Fig. 1, the yoke strips should have two slots to provide for adjusting the position of the magnet before the armature. These slots may be formed by drilling two ¼-inch holes and filing out the metal between them.

The bobbin heads for the two coils should be cut to dimensions from some ⅛ inch fiber and placed over the core, leaving a space of 1½ inches between them. Wind several layers of tough wrapping paper over the cores, and then wind the bobbins full of No. 30 double cotton-covered wire; if enameled wire is used, wind to a depth of about $\frac{3}{16}$ inch. Over the whole coil wind several layers of tough paper and finish with a layer of binder's cloth. The connection between the two coils should be such that the current will flow in the same direction around the two cores, to produce similar poles on the ends of the cores at any instant.

The bobbins *C* (Fig. 4) of the direct-current armature coils are made of $\frac{1}{16}$-inch sheet brass securely soldered together. The bobbin heads are dimensioned at *Q*.

The bobbin support *R* is also made of brass. Drill two holes in the end for holding down screws and drill and tap a hole in the top and bottom for the screws *UB* and *LB*, which form the upper and lower bearings for the armature spindle. These bearing screws should have a cone-shaped hole drilled in their ends to receive the spindle points. The lower bearing *LB* screw is turned in place and after cutting off the head, is soldered on the under side of the support. The upper

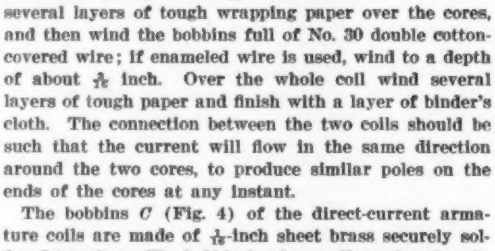

Fig. 3.—Alternating magnet.

bearing screw *UB* should be free for adjustment. The bobbins should be soldered in place after the armature has been mounted; if soldered at this point, the armature cannot be mounted.

The armature *A* (Fig. 5) is a piece of soft iron, 3.32 inch thick. A strip of thin brass, *G*, *F*, is riveted to the side of the armature by the silver contacts *D* and *E*. Sufficient ⅛ inch silver rod (two pieces ¼ inch long) to make these contacts may be obtained from any jeweler for a small sum.

The spindle *B* is a piece of $\frac{1}{16}$-inch steel rod, or a piece of heavy knitting needle having the ends finished to a tapering point which will not bind in the bearing supports. Adjust the armature and spindle so that the armature may move freely in the bobbin and solder the armature and spindle securely together.

The remaining details, such as the assembly of parts, contact screws, etc., are left to the reader. The contacts on *J* and *K*, Figs. 1 and 2, however, should be of silver rod. The ends of *G* and *F* of the brass spring strip on the armature should be bent back to bear against the contacts *L* and *M* with sufficient pressure to keep them always in contact with *L* and *M*.

The transformer is detailed in Figs. 6 and 7. The core should be cut from some good stove-pipe iron, or preferably transformer iron. Sufficient strips of each dimension shown in Fig. 6 should be cut to make a stack 3 inches thick. Then dip half of the strips in shellac and dry them.

The construction of the core will be made clear by reference to Fig. 6, which shows the arrangement of alternate layers of core strips in the finished core. If the two longer and vertical side members of the finished core were removed it would be found that they consist of strips alternately projecting on the ends, leaving an interstice 1¼ inches deep between them. The core is very conveniently assembled in this shape, and after the

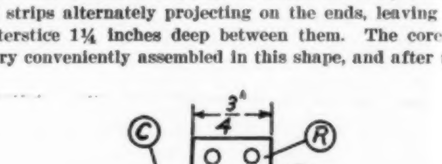

Fig. 4.—Direct current bobbins.

coils are wound on them the short yoke strips are assembled between them.

A simple method of assembling the core is to mount two small pieces of wood on the bench about 6 inches apart, assembling the strips so that alternate pieces touch either end. The shellaced strips should be alternated with the remaining strips. Then remove the core and wrap a layer of friction tape around the solid central portion. When doing this the core should be clamped in a vise so as to compress it as much as possible.

The bobbin heads on each end of the core are cut from ⅛ inch fiber and assembled, leaving a space of 3¼ inches between them. Wrap about six layers of shellaced wrapping paper or bond paper on the core and then wind the secondary of 58 turns per core of No. 12 double cotton-covered magnet wire, winding in layers and shellacing well. Leave out ends of wire long enough for connections, and wrap several layers of insulation over the secondary.

The primary consists of 315 turns of No. 20 double cotton-covered per core. When the primary is wound apply a layer of duck over the whole coil for protection.

Set the two cores side by side with a space of 1¼ inches between them. Insert the yoke strips in the interstices between the core ends across to, but not entering, the other core. Assembling the strips alternately

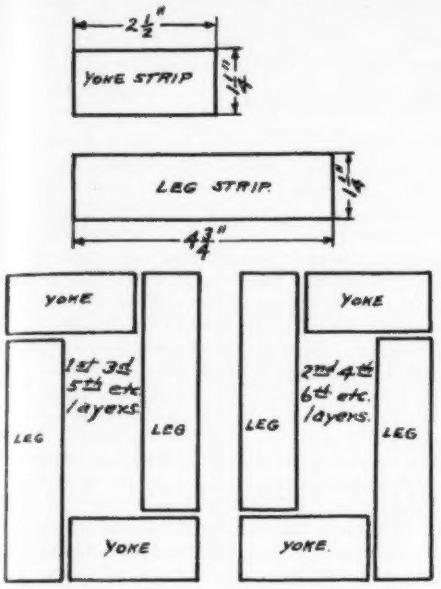

Fig. 6.—Transformer core laminae.

from core to core will build up the end to one solid mass, when it should be inverted and the other end filled in the same manner. The ends of the cores should be clamped between wooden or iron strips to prevent humming.

The connection between the primary coils should be such that the current will flow in opposite directions around the two cores. The secondary coils should be similarly connected.

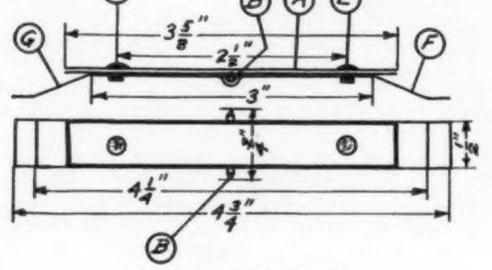

Fig. 5.—Armature details.

The connections between the transformer and the rectifier parts are clearly shown in Fig. 2.

When using for the first time, connect the battery to the direct-current terminals and turn on the primary alternating-current supply. Then adjust the contacts *J* and *K* to touch the armature contacts. It may be necessary occasionally to adjust the spring contacts *L* and *M*, to reduce sparking at points *J* and *K*. If this does not effect the sparking, it may be necessary to employ small condensers *S* connected between contacts *J* and

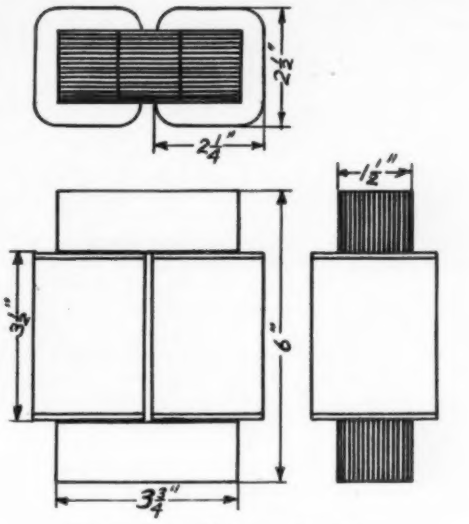

Fig. 7.—Assembled transformers.

K. Small telephone condensers may be used, one being connected on each side. A resistance should be provided to control the charging current.

This converter has the advantage that it will assume of its own accord, the correct polarity for battery charging, and should be found very useful.

The New Internationalism in Agriculture

By H. C. Price

When David Lubin of California laid before the King of Italy in 1905 his plan for the organization of an International Institute of Agriculture, his arguments were based principally upon the necessity of having such an organization in order to secure official and reliable statistics of the world's production of agricultural products. Mr. Lubin has been a very successful merchant in California and had dealt extensively in farm lands. He always had been a close student of economics and he saw that the fundamental problems of agriculture are not national problems, but world problems; that the progress of agriculture, the foundation of all other industries, determines the progress of the peoples of the world materially, intellectually, and morally; that the greatest problem facing every nation is to feed and clothe its people.

ORGANIZATION OF INSTITUTE.

Many propositions have been made and plans outlined for an international agricultural organization, but nothing tangible ever resulted from them until Mr. Lubin presented the matter to King Victor Emanuel III of Italy. Mr. Lubin's statement of the purpose of the organization was as follows: "The chief purpose of the International Institute of Agriculture is to remove the obstacles which now impede the operation of the law of supply and demand. This will be accomplished by the gathering, summarizing, and disseminating of information on the world's supply of the staples of agriculture, said information to be timely, available in form and to be composed mainly of (a) the stock on hand, and (b) the condition of the growing crop."

The King of Italy called a conference of representatives of the nations of the world in Rome, May, 1905, and as a result of their deliberations provisions were made for the establishment of a permanent International Institute of Agriculture, with headquarters in Rome. King Victor Emanuel showed not only his interest in the Institute by giving it his official support, but from his private fortune he built a magnificent building for its use, and contributes $60,000 per year to its support, aside from the support given it by his government.

Practically all the nations of the world are represented in the Institute and make yearly contributions to its support, and are officially represented in its permanent committee, as shown by the following list:

Germany	New Zealand
Argentine	Mauritius
Austria	South African Union
Hungary	Greece
Belgium	Italy
Brazil	Eritrea and Italian Somaliland
Bulgaria	Japan
Chile	Luxemburg
China	Mexico
Costa Rica	Montenegro
Cuba	Nicaraugua
Denmark	Norway
Ottoman Empire	Paraguay
Egypt	Holland
Ecuador	Peru
Spain	Persia
United States	Portugal
Ethiopia	Roumania
France	Russia
Algeria	Salvador
Tunis	San Marino
Great Britain and Ireland	Servia
Australia	Sweden
Canada	Switzerland
British India	Uruguay

THE WORK OF THE INSTITUTE.

The Institute was formally opened in May, 1908. In the beginning there were almost endless difficulties in getting its work established. In the matter of statistics, for example, scarcely any two nations used the same method of reporting their agricultural productions, and some nations had no crop-reporting systems whatever. The Institute, as it is now constituted, is the clearing house of the official agricultural statistics of the world. Each month the officers in charge of the statistical work of the various nations cable to the Institute by a specified day of the month their monthly crop report. The statisticians of the Institute from these reports make up the world's statistics for the month and cable them back to the respective nations. In this way absolutely official reports are made without any opportunity of private interests influencing them.

WORK OTHER THAN STATISTICAL.

Although the statistical work was the primary purpose for establishing the Institute, yet two other lines of work have been already established that promise to be almost as valuable as the statistical work. These lines of work are Plant Diseases and Agricultural Economics. Plant diseases know no national boundaries, and their control and eradication concern all nations. The Institute has a staff of scientists whose work is primarily to collect all information known and all that has been and is being accomplished in the control of plant diseases in the various countries, and each month a bulletin of about 250 pages is published, giving a summary of what is being done in the various countries in this line. Thus in this way this work is to the control of plant diseases what the Department of Statistics is to the statistical work of the various nations. It serves as a collecting and distributing agency, giving the benefit of what is accomplished in one nation to the other nations as soon as possible.

In agricultural economics the Institute thus far has been working on the problems of agricultural co-operation, insurance and credit. A monthly bulletin of 250 pages is published, in which official reports of what has been accomplished in the different nations in these lines, as well as reviews of the annual reports of the organizations themselves and current literature concerning them. Although these bulletins have been published less than three years there is already contained in them concerning these subjects more information than is found any place else. The bulletins not only serve in distributing information, but they are important agents in promoting the development of agricultural organizations along these lines.

A FACTORY IN AGRICULTURAL EDUCATION.

In the Institute is rapidly accumulating the literature of agriculture for all nations, and in the future it will offer opportunities for the special student in agriculture that cannot be equaled any place else. The library not only receives the official agricultural reports of the respective governments, but also the more important agricultural works published. The same thing is true of the current literature, and the Institute now receives about 2,000 agricultural periodicals. These are reviewed and the subjects of the more important articles published in the monthly bulletins.

The official language of the Institute is French, but the Statistical bulletins are published in five languages—French, German, Italian, English and Spanish. The bulletins on Plant Diseases and Agricultural Economics thus far have been published in French, Italian and English.

OPPOSITION TO THE INSTITUTE.

Like every good thing, the Institute has had considerable opposition to overcome. Private interests that in the past have been concerned in furnishing world's estimates of agricultural crop production have been actively opposed to its work. In our own Congress members who were doubtless misinformed as to the real purposes and work of the Institute have opposed the small appropriations made for its support. They have charged that its work was all visionary and useless and that it simply served to furnish a lucrative position for a Government representative in Rome. But nothing could be further from the truth. Mr. Lubin, who has been the representative of the United States in the Permanent Committee of the Institute since its organization, is a man of fortune and has never accepted any salary or even his expenses for his services. Anyone who has seen the work the Institute is doing and has talked to the men working in it, cannot realize how any legislator, who is correctly informed, could be honestly opposed to the support of the Institute.

A FACTOR FOR INTERNATIONAL PEACE.

The work of the Institute is having a secondary effect in promoting the world's peace—an effect of no little importance. The late Wm. T. Stead, who had been so active in the World's Peace Movement, said that in his opinion the work of the International Institute of Agriculture was of no less importance than the Peace Conference of the Hague in promoting universal peace.

The Hon. David J. Foster, chairman of the American delegation to the General Assembly of the Institute, in May, 1911, touched upon this in an address to the Assembly in the following words:

"This delegation wishes to state to the Assembly the profound impression made on it by seeing gathered in this hall the representatives of all the nations of the earth, convened together not to discuss the interests of one country or of one people, but the economic interests of the whole human family.

"As the eminent delegate of Chile remarked in this morning's debate, the primary need of our civilization is to have at a fair price an abundant supply of the staples of agriculture, which are the daily bread and clothing of the people.

"The peoples of the earth pray every morning for their daily bread, and the problem which this Institute has to solve is to so regulate the relations between consumers and producers that this daily bread may be bought and sold at a price which will be fair to both.

"By solving this dual problem we shall strengthen the nations in their sovereignty, bind the world together in the new internationalism and hasten the dawn of the day of the lasting peace of God."

Icebergs and their Detection*

The International Ice Patrol and the Valuable Work Accomplished by It

ICEBERGS and derelicts have for many years been the dread of trans-Atlantic navigators, particularly along the lanes that run near the Grand Banks of Newfoundland. In the days of slow steamers most of the vessels took a course directly across the banks, which carried them through the ice zone during a large portion of the year. Since the advent of large and fast steamers agreements have been entered into whereby definite routes have been established to the southward of the normal ice zone. If the ice zone were fixed nothing further would be required to assure reasonable safety along these routes, but unfortunately the limits of ice fields and bergs vary considerably, in location as well as in season, and consequently a vessel might sail on a course that was clear at the time of her departure, but encounter ice which had drifted into her path before she reached the Grand Banks.

Up to 1912 nothing had been done toward the establishment of any system for guarding against the danger from floating ice, but on April 14th of that year, when the giant passenger steamer "Titanic" was sunk on her maiden voyage by striking an iceberg, there arose an almost universal demand for a patrol of the ice zone to warn passing vessels of the limits of danger from day to day during the ice season.

The Navy Department met this demand by detailing the scout cruisers "Chester" and "Birmingham," which immediately took up the patrol of the ice regions and continued throughout the dangerous period that year.

In the spring of 1913 marine interests again applied to the Navy Department to perform the ice-patrol duty, but that department had no vessels to spare for the purpose. Application was then made to the Treasury Department, and the Secretary of the Treasury selected the revenue cutters "Seneca" and "Miami" for the work, those cutters being deemed best fitted for it on account of their comparatively large cruising radii.

The work of these two cutters embraced the months of April, May and June, during which they alternated on patrol, each vessel taking 15 days on the patrol and 9 days in Halifax, Nova Scotia, each month. The remaining six days were consumed in making the trip from Halifax to the patrol grounds and return.

Besides the regular work of locating the ice and warning passing vessels of the danger limits, the officers of the cutters were directed to make a study of the ice situation, particularly as to the currents in the vicinity of the Grand Banks, the physical properties of the ice, its drift, erosion and melting; temperatures of sea water and atmosphere in the vicinity of ice; habits of birds and seals with regard to ice, and, in short, to gather all sorts of information that might help the navigator in those regions.

The patrol of 1913 was most satisfactory. The reports of the commanding officers of the patrol vessels contained many interesting features, and the department has received several flattering testimonials from masters of vessels and others who had been in a position to appreciate the work that had been done.

The British Government also took up the question of ice observation and ice patrol for the season of 1913, with the result that the steam trawler "Scotia" was chartered and fitted out for this service, the expense being shared by the British Board of Trade and the various British steamship companies operating trans-Atlantic lines. The work of the "Scotia" was confined almost entirely to ice and weather observations off the coast of Newfoundland, and this work was greatly hampered by fog and storm. Nevertheless, much useful information was gathered and the "Scotia" co-operated with the revenue cutters, so far as conditions permitted, in disseminating ice information to passing vessels.

At the International Conference on the Safety of Life at Sea, which was convened in London on November 12, 1913, the subject of patroling the ice regions was thoroughly discussed, and the convention signed on January 20, 1914, by the representatives of the various maritime powers of the world, provided for the inauguration of an international derelict-destruction, ice-observation and ice-patrol service, consisting of two vessels, which should patrol the ice regions during the season of danger from icebergs and attempt to keep the trans-Atlantic lanes clear of derelicts during the rest of the year. The Government of the United States was invited to undertake the management of this triple service, the expense to be defrayed by the 13 powers interested in trans-Atlantic navigation in a fixed proportion which was definitely agreed upon, subject to ratification by the law-making bodies of the governments concerned.

The convention, when ratified, would not go into effect until July 1, 1915, and as this made no provision for continuing the ice patrol during the seasons of 1914 and 1915, the Government of Great Britain, on behalf of the several powers interested, made inquiry on January 31, 1914, as to whether the United States would be disposed to undertake the work at once under the same mutual obligations as provided in the convention. The proposition was favorably considered by the President, and on February 7, 1914, he directed that the Revenue-Cutter Service begin, as early as possible in that month, the international ice observation and patrol service. On February 11 orders were issued to fit out the "Seneca" for that duty, and on February 19 she sailed for the Grand Banks.

The "Seneca" was directed to make ice-observation cruises, with headquarters at Halifax, Nova Scotia, until such time as a continuous patrol should be necessary, when she would be joined by the "Miami," the two vessels alternating on patrol during the dangerous season in the same manner as during the season of 1913.

The "Seneca" reached the Grand Banks on February 24, and after locating the southern limits of the ice and determining its drift, proceeded to Halifax for coal and provisions. This work was continued, the "Seneca" making observation cruises to the ice fields, using Halifax as a base, until April 1, when the continuous patrol was established and maintained until July 1. By the latter date the ice had ceased to be a menace to the southern lanes and the patrol was discontinued for the season.

The "Miami" then returned to the United States and the "Seneca" was detailed to make a special cruise for the purpose of obtaining oceanographical and meteorological data between St. Johns, Newfoundland, and Greenland, and also from Flemish Cap to the tail of Great Bank.

The "Seneca" sailed from Halifax on this mission July 5 and cruised as far north as ice conditions permitted. She then made a series of tidal and current observations from St. Johns, Newfoundland, to the tail of Great Bank, thence to Flemish Cap, and thence to St. Johns. During this cruise she also ran lines of soundings which will prove valuable in checking up existing records for that vicinity.

Upon the request of the Secretary of the Treasury, the Secretary of Commerce detailed scientists from the Bureau of Standards and Bureau of Fisheries to the "Seneca," and also supplied apparatus for taking meteorological and oceanographical observations and collecting specimens of plankton. These scientists accompanied the "Seneca" throughout the ice-patrol season and during the special cruise in July. The data they gathered will prove of great value in clearing up many of the problems of ice movement and ocean currents.

In dispatching the "Seneca," on such short notice, to observe and study ice conditions, it was impossible to provide all of the instruments necessary for the scientific observers. This difficulty, however, was overcome through the hearty co-operation of the British Board of Trade, which tendered to the United States Government the apparatus used by the "Scotia" the previous season. The generous offer was highly appreciated and gratefully accepted, and the apparatus thus provided has enabled the scientific party on the "Seneca" to conduct their investigations in a more comprehensive manner than would otherwise have been possible this season.

Having completed her work, the "Seneca" returned to Halifax and shortly thereafter was directed to return to her regular station.

All ice information collected by the vessels on ice-observation and ice-patrol duty, whether from original observations or from authentic reports of other vessels, was sent out broadcast twice a day. Each message was repeated three times, using 300-meter waves in the first set of warnings and 600-meter waves in the second. If the ice conditions were unusually serious, messages were sent more frequently—sometimes as often as once an hour.

Besides this broadcast warning to commerce, the patrol vessels sent daily radiograms via Cape Race radio station to the branch Hydrographic Office, United States Navy, at New York. Upon being received at that office, the messages were made public by telephone and by memoranda to the shipping offices, Maritime Exchange, and others interested. The branch Hydrographic Office was kept open beyond the statutory hours for this purpose. That office also telegraphed each message to the Hydrographic Office in Washington, where the information was circulated in the Daily Memorandum, which goes to each branch office, and was also broadcasted by radio from the Arlington Naval Radio Station.

The Hydrographic Office cabled the substance of these messages to the Deutsche Seewarte, at the request of that institution. The same information, together with all other ice reports, was published from week to week in the Hydrographic Bulletin, and finally appeared in graphic form each month on the pilot charts.

Besides co-operating in the dissemination of ice information, as above set forth, the Hydrographic Office, at the request of the captain commandant of the Revenue-Cutter Service, drew up a plan for observing and reporting upon ice conditions, based upon the instructions to patrol vessels for the seasons of 1912 and 1913, and another plan for the collection of hydrographic information used by the "Seneca" on the special cruise in July.

During the season of 1914 many observations were some underwater signaling device little reliance apparmight be located at night or in a fog, but outside of some underwater signaling device little reliance apparently can be placed on any. These include the temperature of the water, echoes and the presence of birds.

In the following a few notes and extracts from the detailed logs of the two observing vessels will be given.

In regard to the temperature of the water in the neighborhood of bergs, the report states:

"At several times a small boat was used to obtain temperatures close around bergs. On April 12 a series of temperatures around a large berg were taken. At 800 yards the temperature was 0.4 degrees, gradually going down to 0.1 degree at 200 yards; the temperature then rose a little, and at 20 feet it stood at 0.3 degree; on the opposite side of the berg at a distance of 20 feet the temperature was 0.1 degree. Around another berg in warmer water the temperature on one side at 20 yards was 1.9 degrees and on the opposite side 3.1 degrees. Away from the berg irregular temperatures were obtained with no definite trend. At another berg in still warmer water temperatures on two sides at a distance of 50 feet were 4.9 degrees and 5.2 degrees. Temperatures were then obtained at every 30 yards to a distance of 1,000 yards. The temperatures increased very irregularly to 6 degrees.

"The effect of bergs on the temperature of the sea water is at most very small, even in the warmer water. The temperature on approaching bergs is often very irregular, with no definite decrease or increase. If there are temperature effects due to bergs they are not distinguishable from the irregular variations observed."

On clear days there was no difficulty in distinguishing icebergs at quite a distance, and it is noted that one berg was seen when twenty miles away; but in the dark conditions generally were reversed. One comment is significant. The report says: "At night we experimented with the searchlight, but found it to be of little use. We could see farther at night with the naked eye and marine glasses, distance about 2 miles."

It has been stated that the presence of birds was a good indication of the presence of bergs or ice fields; but the observations made on these observation cruises show quite conclusively that this indication is of no significance whatever.

It has been supposed in some quarters that the presence of an iceberg could be ascertained with considerable accuracy by means of echoes, but this indication appears to be as groundless as all of the others, that is as far as air echoes are concerned. On one occasion Capt. Quinan, of the Cutter "Miami," reports: "We stopped near the largest berg and by range finder and sextant computed it to be 450 feet long and 130 feet high. Although we had gotten within 150 yards of the perpendicular face of this berge and obtained no echo from the steam whistle, Professor Fessenden and Mr. Blake obtained satisfactory results with the submarine electric oscillator placed 10 feet below surface, getting distinct echoes from the berg at various distances from one-half mile to $2\frac{1}{2}$ miles. These echoes were not only heard through the receivers of the oscillator in the wireless room, but were plainly heard by the officers in the ward room and engine room store room below the water line. Sound is said to travel at the rate of 4,400 feet per second under water. The distance of the ship, as shown by the echoes with stop watch, corresponded with the distance of the ship as

* Extract from Treasury (Dept.) *Bulletin*, No. 3, U. S. Coast Guard.

determined by range finder. On account of the great velocity of sound through water, it was our intention to try the oscillator at a greater distance for even better results, but a thick snowstorm drove us in to shelter on the Banks again.

"On the morning of April 27, anchored in 31 fathoms of water with 75 fathoms of chain in order to make current observations. Professor Fessenden also took advantage of the smooth sea to further experiment with his oscillator in determining by echo the depth of water; the result giving 36 fathoms, which seemed to me very close."

On another occasion when this same berg was encountered the report states: "At a distance of 400 yards, ship and berg at an angle of 90 degrees to axis of wind, we obtained an echo from the steam whistle on one side but none on the other, although the walls on both sides were high and perpendicular." And in the case of another berg an excellent echo was obtained from all sides within a distance of half a mile. "But to summarize: Echoes—that is, air echoes—are erratic and not to be relied upon; there is no appreciable change of temperature, air or water, when approaching a berg. If a fresh wind be blowing and you get within a hundred yards or so to leeward, one experiences a sensation of cold, but the thermometer may not register any drop. And when a ship unwittingly gets that close to a berg, she would be in serious danger. Birds do not indicate presence of ice. They are more numerous around vessels where they can find something to eat. There is no iceblink over a berg as some have asserted, but we noticed the blink over field ice. The mariner must depend on his eyesight alone; he should navigate cautiously in a fog or at night, and keep to the southward when passing the ice zone."

One explanation of the reported echoes from icebergs in foggy weather is suggested by the following extract: "On the morning of the 22d, I read in the press news from New York: The British steamer 'Isle of Mull' arrived to-day from Lisbon and reports on June 16, while crossing in latitude 40 degrees 40 minutes N. (no longitude given) in dense fog, steaming slowly, sounding whistle at frequent intervals, suddenly startled by quick return sound. Steamer stopped, whistle sounded again and again with the same return of sound. Steamer then steered away from course until return sound no longer heard. Captain believed that they had narrow escape from collision with iceberg.' I knew that there were no icebergs in that latitude and the captain must have heard the reverberation of his own whistle. I have had a similar experience, have experimented a number of times since in fog, when I knew there were no bergs within 50 miles of the ship, and occasionally got reverberations resembling echoes so pronounced as to be startling. I find that this effect can be obtained only when calm or wind very light."

The work of the Ice Patrol has been most successful and valuable, for not only have the warnings sent out been the means of diverting many vessels from dangerous courses, but the scientific information that has been collected and the various physical observations that are being constantly made, will be of great future benefit to navigation.

Some Notable Tests of Car Resistance

There are plenty of data available in railway literature on the resistance of railway trains. Few experiments have been made, however, to determine the resistance of individual cars. The practical value of such tests will be evident to every engineer who has the responsibility of constructing a freight yard with one or more tracks down which cars are to run by gravity. The grade must be steep enough so that a car will not come to a stop upon it, but not so steep that the car will reach a dangerous speed in case it is running free without a brakeman. The problem comes in on a large scale in the design of gravity sorting yards.

To obtain accurate data for use in constructing such yards an elaborate series of tests has been carried out by Prof. C. L. Eddy of the Case School at Cleveland. The tests were made in the gravity sorting yard of the Lake Shore & Michigan Southern Railway at Collinwood, Ohio. A full description of the tests is given in a paper by Prof. Eddy in the *Bulletin* of the American Railway Engineering Association for March.

The method of making the tests was simple. Cars which were pushed over the hump in the ordinary routine operation of the yard had their velocity accurately determined to 0.01 second by an electric chronometer as they passed two different points on the south ladder track about 400 feet apart. By comparing the change of velocity of the cars in passing over this stretch of track with the force imparted to the car by the downgrade of the ladder track, 1.135 per cent, the resistance of the car was accurately determined. The speeds of the cars were generally low, the range being from 8 to 15 miles per hour. The wind velocities at the time of the test were generally not over 20 miles per hour; hence the air resistance to the motion of the car was in general small and could practically be omitted from consideration.

Passing now to the discussion of the results obtained from the tests, the first notable feature is the high average resistance observed. This average was 21.7 pounds per ton in one series of tests and 22.3 pounds per ton in the other series, made a year later. A part of this high resistance is explained by the fact that the cars were running down the ladder track over switches and frogs, where the resistance is undoubtedly more than an ordinary unbroken rail. Another factor, probably, in producing the high resistance is that the cars had run only a short distance at the time their speed was taken. It may be assumed that the cars to be sorted had been standing in the receiving yard long enough at least to have the journals cool off before they were pushed over the hump by the drilling engine. Various tests indicate that car resistance is materially reduced after a car has run far enough to have its journals well warmed. A set of observations made when the thermometer was at 20 deg. Fahr., which were not included in the average given in the preceding, showed a car resistance of 26.8 pounds per ton, conforming to the well-known rule that car resistance increases as the temperature lowers.

All these figures for resistance, as stated before, are exceedingly high compared with the formulas in general use for computing train resistance. For example, Henderson's formula for the resistance of trains behind the tender at a speed of 10 miles per hour is $R = 3.5$ times the weight of the train in tons + 50 times the number of cars in the train. The second term in this formula is added to allow for the increased resistance of empty cars over loaded cars. By this formula the resistance of a single car weighing with its load 50 tons would be 4½ pounds per ton, or less than one fourth that shown by Prof. Eddy's tests. Other formulas in general use give a train resistance of only 5 to 7 pounds per ton for modern high-capacity cars. There are, in fact, no train-resistance tests on record which show any such high resistance to the movement of the car as is indicated by these tests of single cars by Prof. Eddy.

Besides the high resistance of the cars tested, the wide variations in the resistance of the cars is a noteworthy feature. A few of the cars showed very low resistance, one as low as 4½ pounds per ton and another 6 pounds per ton. These results were so far below all the other results obtained that some error may possibly have occurred in the observations or computations. A large number of the cars tested, however, showed resistances of from 11 to 16 pounds per ton.

At the opposite extreme, certain cars showed phenomenally high resistance. One car showed a resistance of 41.8 pounds per ton, another of 36.3 pounds, another of 35.6 pounds, while several were above 30 pounds. It is comparatively easy to account for these clearly exceptional cases of exceptionally high resistance. The brake rigging may have been stiff enough to keep the shoes pressed against the wheel, or trucks out of square may have caused the flanges to hug the rail and produce particularly high resistance in running over the switches and frogs.

That a considerable variation in resistance of cars does occur is a matter of common observation in the operation of gravity switching yards. Probably the largest element in variation of car resistance is journal friction. It is known from both laboratory tests and from practice that a car journal in first-class condition with a well-fitting bearing, thoroughly lubricated, will run with an extremely low coefficient of friction when once the film of oil is established between the journal and the bearing. On the other hand, it is well known that under the actual conditions of railway-freight-car operation, with the lubrication and packing of journal boxes performed at irregular intervals, with wide variations in the condition of the journal, the wear of the bearing and its adjustment, there is a wide variation in the friction of car journals. It is probable that these variations alone would be sufficient to account for most of the range between the higher and lower values found in Prof. Eddy's tests.

In analyzing the results of his tests Prof. Eddy concludes that in gravity classification yards, if it is desired to insure that there shall be no slackening of speed of the cars while running down the ladder from which the classification tracks lead, the grade of the ladder should be 1.65 per cent. If this were done, however, it would be necessary to apply brakes on nearly all the cars to control their speed and prevent them from striking the turn-out curve at a speed too high for safe operation. On the Collinwood ladder track, with its grade of 1.175 per cent, cars with the average resistance ran down the ladder at practically uniform speed. Cars of higher resistance than the average slackened speed and the cars of lower resistance gained in speed. There were, however, very few cars tested whose speed increased to materially over 15 miles per hour in running down the ladder. On the other hand, the cars which slowed down did not slacken speed enough to offer any serious hindrance to operation; and it may be questioned, therefore, whether it would be wise to increase the ladder track to the extent suggested by Prof. Eddy.—*Engineering News.*

A New Method of Disinfecting Wounds

Two experienced French bacteriologists, Prof. Leclainche, chief of the sanitary service connected with the Agricultural Department, and Prof. Vallée, head of the veterinary institution of Alfort (Paris), have obtained a specific serum which is said to have produced most striking results in the treatment of infectious wounds. Researches made during the last few years demonstrated the possibility of using a serum of this kind as the sole means of producing a thorough disinfection of wounds, that is, it consists in a purely physiological method of destroying the numerous germs which have such a harmful effect upon wounds, and delay their cure. It is claimed that the new treatment will discard all chemical antiseptics. While these prevent the action of microbes on one hand, it is also true that they tend to paralyze the cells which are occupied with the curative action by the formation of a cicatrice. It is well known that the different therapeutic serums are obtained by injections into the veins of horses, such consisting of doses of microbe culture of increasing strength. The animal's system gradually becomes accustomed to the infection, and it reacts by forming antitoxines, or counterpoisons, which accumulate in the serum; whence it follows that such serums can neutralize toxines produced in a human patient by this same microbe. In order to obtain the new serum which we mentioned, the authors operate in like manner upon a horse, but introduce not only one but all the varieties of microbe which are concerned in wounds caused by war. In this way the serum acts against the numerous microbes of gangrene and of suppuration, counteracting the increase of such microbes which is one of the great troubles at the surface of infectious wounds. In short, the new serum reacts against all these germs at the same time. Before this it was noticed that the ordinary serum of the horse when placed upon wounds favors the destructive action of the human cells upon microbes, and strengthens such cells, stimulating their action. On the new system, by means of the specific antitoxines, the serum not only excites the cell action against the microbes (phagocytose), but acts in a direct manner on the microbes so as to destroy their toxic effect and the result is their total destruction. Direct contact of the new serum with wounds is made by surface application by bandages, or by injection into cavities. It is stated that numerous surgeons have already used the method with success upon widely varying classes of wounds, especially those caused by the war, traumatisms, abscesses, gangrene, ocular infections, burns and frost-bites, etc. In all such cases the results were most striking. By its physiological qualities the new serum forms a protective layer which is most favorable to the rapid regeneration of the parts, to the success of grafted portions, or preservation of parts of skin or muscle which without that would need to be removed. In short, the serum is a remarkable aid to preservative surgery. When applied, the pain is reduced or disappears almost at once, and suppuration ceases within 24 or 48 hours. Healing up of wounds is remarkably rapid, and the fever due to the microbe ceases during the first application of the serum, showing the powerful anti-toxic action. The wound becomes cicatrized within a short time, thus lessening the duration of the healing, and such cicatrices are formed in the best conditions. The mental condition of the patient is improved by the fact that he perceives the rapid healing and the good general effect upon the system, thus being assured of a rapid cure. A point to be noticed is that the new serum guarantees the wounds against any complications, because of the excellent physiological antiseptic effect which is produced. At the present time there are used twenty-five horses for the preparation of the serum at the Alfort veterinary establishment near Paris, and each month they furnish about 40,000 doses of 5 c. c., these being exclusively used in the ambulances and military hospitals. But measures will no doubt be taken to increase the production of this remarkable serum in order that it can be used on a larger scale.

Agricultural Lime

The use of lime as a fertilizer dates from the inception of modern scientific farming. Agricultural chemists have shown that there are five or six different functions which lime may perform to benefit a soil, which may be summarized briefly as follows:[1] 1. It is an essential element of plant food. 2. It aids in the conversion of decaying organic matter into humus. 3. It forms compounds with the humic acids which tend to prevent their being leached out of the soil and lost. 4. By producing proper sanitary conditions the growth of injurious bacteria is largely prevented, while the growth of nitrifying bacteria is encouraged. These nitrifying bacteria convert the nitrogen of the humus into a form such that it is available as a plant food. 5. Lime aids in the liberation of potash and phosphorus from inert compounds. 6. It tends to flocculate clay soils, rendering them granular and more porous.

Obviously, permanent results can not be expected unless care is taken to insure the presence of some organic fertilizer at all times. Lime used alone may be temporarily beneficial, but will eventually be harmful; when used with cowpea vines it becomes more efficient for general purposes than almost any other fertilizer.[2] Of course, lime is not beneficial to all crops to the same extent, and not all soils need lime. Thus, some of the common plants may be classified according to the extent to which they are benefited by lime, as follows:[3]

PLANTS BENEFITED OR INJURED BY LIME.

Benefited	Slightly benefited	Slightly injured	Injured
Spinach	Indian corn	Cotton	Radish
Lettuce		Tomato	Flax
Beet		Cowpea	Blackberry
Celery		Concord grape	Black raspberry
Onion		Peach	Cranberry
Cucumber		Apple	
Cantaloupe		Pear	
Asparagus			
Cabbage			
Peanut			
Rhubarb			
Pea			
Pumpkin			
Bean			
Tobacco			
Alfalfa			
Clover			
Barley			
Wheat			
Oats			
Timothy			
Gooseberry			
Currant			
Orange			
Quince			
Cherry			

Whether a soil will respond to liming or not depends on the amount of available calcium oxide which it already contains. Unfortunately chemical analysis does not distinguish between the total calcium oxide and that which is available to plants. Probably the best indication of the need of lime is the failure to obtain a good crop of clover.[4]

Whether high-calcium or magnesian lime should be used as a fertilizer is a question which has received wide attention from agricultural chemists. It is generally conceded that some magnesia is necessary for the growth of most plants, but that too much of it acts as a poison. However, magnesium carbonate is more soluble than calcium carbonate (in the laboratory, 1 part of the former dissolving in about 5,000 parts of pure water, and 1 of the latter in about 10,000 parts of pure water) and therefore may be more apt to be leached out of the soil by rain. Hence most soils contain more calcium than magnesium, and the use of a magnesian lime should be at least not detrimental. This has been found to be the fact.[5] It may be stated that, for the crops ordinarily raised, the lime to be used as a fertilizer should be so selected that the final ratio of lime to magnesia available in the soil should be about 7 to 4.[6]

The question as to whether lime should be applied to the soil as quicklime, hydrated lime, air-slaked lime, or ground limestone is still the subject of a great deal of controversy. The advocates of ground limestone claim that the caustic properties of quick or hydrated lime will burn up and destroy the organic matter in the soil, whereas limestone can be applied in large quantities at long intervals and will therefore produce a more or less permanent fertility.[7] The advocates of lime claim that one of the main functions which lime has to perform is the destruction of the organic matter and the liberation of the nitrogen in a form such that the plant can use it; that the frequent and judicious use of lime, together with some organic fertilizer, will bring immediate results.[8] Of course the local conditions of each particular case must be considered before a final conclusion can be reached. Thus, it is rational to use quicklime on soils which are exceedingly rich in organic matter, such as peaty or swamp soils.[9] Limestone is safer than quicklime when applied just before planting a crop which is little helped by liming, or when applied to a light sandy soil in hot dry weather.[10]

It will be noted that the value of lime as a fertilizer depends largely on the available calcium oxide which it adds to the soil. This depends partly on the calcium oxide present in the material and partly on the size of the grain, which governs its immediate availability. Pure quicklime contains 100 per cent calcium oxide; pure hydrated lime, 76 per cent; and ground pure limestone, 56 per cent. The farmer must pay the cost of freight, hauling and distribution on 0 per cent, 24 per cent, or 44 per cent of inert material. It costs least to apply ground limestone and most to apply quicklime. It is generally not economical to grind limestone to the same degree of fineness as burned or hydrated lime. Based on these considerations, the statements have been made that 50 pounds of quicklime are equivalent as a fertilizer to about 60 pounds of hydrated lime, 100 pounds of air-slaked lime, or 250 pounds of ground limestone; and that at present prices, and taking into account the freight and hauling, quicklime will be found the most economical.[11]—*Mineral Resources U. S., Part II, U. S. Geological Survey.*

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[8] Wheeler, H. J., Is the recommendation that only ground limestone should be used for agricultural purposes a sound and rational one?: Nat. Lime Mfrs. Assoc. Trans., 1912.

[9] Hopkins, C. G., loc. cit.

[10] Wheeler, H. J., loc. cit.

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Destruction of Flies and Disinfection

Questions of disinfection have become of serious importance at the battle front in Europe with the coming of hot weather, and various methods of procedure have been suggested. In a recent issue of *Nature*, some consideration is given to a paper by M. E. Roubaud, that appeared in the *Comptes Rendus* of the Paris Academy of Sciences. The author remarks that the hot weather will bring with it the menace of fly outbreaks and consequent epidemics of diseases, and that he has collected the simplest methods of dealing with the problem. For house-flies, he recommends heavy coal-tar oils sprayed on the surface of excrement, etc., to prevent access of flies; for sanitary purposes he advises the following:

Ferric sulphate	2,500 grams.
Heavy tar oil	500 c.c
Water	10 liters.

This is stated to be deodorizing, larvicidal, and protective against flies.

Heavy tar oils are toxic to plants, and cannot be used when the material is to be employed as manure. Shale oils (miscible oils) he considers more toxic to plants than to larvæ, and he deprecates their use. Cresyl—i. e., miscible cresol—at 5 per cent in water is not harmful to plants, and manure heaps are to be treated with 15 liters (4 gallons) per superficial cubic meter. The exposed areas of the manure heap are then to be protected with a watering of 10 per cent solution of ferric sulphate. This double treatment is to be carried out twice, in June and in August; fresh manure as added is to be treated with ferric sulphate.

In regard to blow-flies, M. Roubaud discusses means of preventing access of flies to dead bodies, and the disinfection of corpses. In the first he states that heavy tar oil is to be used, as it preserves animal tissues when 10 per cent cresyl, chloride of lime, formol, milk of lime, and 5 per cent phenol fail to do so. Ferric sulphate is to be used as a protective covering, either powdered on or applied as 10 to 20 per cent solution. The salt forms stable compounds with the tissues which cannot be attacked by flies, and the solution kills eggs and larvæ; the three substances required at the front then are ferric sulphate, heavy tar oil, and cresol.

Some of the author's statements, which are given without proofs, cannot be unreservedly endorsed; for example, it is practically certain that a dead horse powdered with ferric sulphate will still breed innumerable flies unless it is periodically treated. No superficial treatment will clear a superficially dry manure heap of maggots; only a vapor treatment applied in liquid form. Also, a 10 per cent solution of ferric sulphate is a very expensive dressing unless the subtance is freely available in enormous amount; and one of the chief difficulties at the front is the transport of large quantities of material. Concentrated treatments are required if possible, not 10 per cent treatments at great bulk.

The problem of dealing with flies is very difficult, and is receiving much attention. One aspect is being carefully dealt with in this country, and the results will be available very shortly. This is the question of the treatment of the great aggregation of stable manure. The War Office have apparently accepted the American view of the value of borax; already a treatment with volatile liquid at a third of the present cost of borax has been found, which is satisfactory in that it spreads in the manure heaps and is not simply a superficial treatment; and it does not affect the value of the manure for horticultural purposes. Plants will stand very strong applications of volatile organic compounds, far stronger than are required to kill fly maggots, but which compounds are the best has yet to be determined.

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